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AN APPRAISAL OF RESEARCH IN PROGRAMMED INSTRUCTION

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "An Appraisal of Research in Programmed Instruction" submitted by John Strembitsky in partial fulfilment of the requirements for the degree of Master of Education.

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ABSTRACT

This documentary analysis consisted basically of an evaluative survey of experimental reports concerning the field of programmed instruction. The purpose was to identify and evaluate, as objectively as possible, the answers, in terms of research findings, to a set of questions considered most important to the utilization of programmed instruction. The method involved a modified version of a technique formerly utilized by Monroe and Engelhart in evaluating research done in mathematics. To make the results of the study more suitable for administrative purposes, the modified version included a list of eight criteria compared to five used by Monroe and Engelhart. The criteria involved the following aspects of research: (1) definition or explanation of terms, (2) size of samples used, (3) duration of the experiments, (4) pretesting relevant to the subject matter, (4) reliability of the instruments, (5) error rates of the programs, (6) equating of groups, and (8) statistical treatment of data. The criteria were applied to two hundred two experimental research reports, a process which yielded an evaluative reliance index for each individual report. The results of the individual evaluations were then applied to specific findings identified by the detailed analysis. This application in form of a dependability level formula served to assess the findings as being or not being highly dependable in assisting the formulation of decisions concerning the utilization of programmed instruction.

The evaluation of the individual studies revealed that the explanation of terms, the error rate of the programs and the reliability of the instruments were the least satisfied items of the criterion list. The equating of groups and the statistical analysis of data were most adequately represented.

Of the many findings identified as answers to the questions posed in the study, relatively few were found to be highly dependable in terms of the standard set by the dependability level formula. Programmed instruction was found to be at least as effective as conventional methods in teaching the recognition of words in spelling and reading to retarded students. Programmed instruction and conventional methods were found to be equally effective in teaching certain aspects of mathematics to mixed ability groups at the junior high school level. There appeared to be no difference in the effectiveness of the two methods in teaching most aspects of mathematics at the college level. The greatest number of highly dependable findings were revealed in English at all levels of achievement and ability where the traditional methods and programmed instruction were found to be equally effective in most cases.

With respect to the program characteristics, there appeared very little difference in the effectiveness of the various characteristics in achieving the different educational objectives.

Finally, the highly dependable findings supported the conclusion that programmed instruction did not serve to reduce the dependence of the learner upon his ability to learn.

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THE INTRODUCTION

Much has been said and done in the field of programmed instruction during the 1960's. Just as any other new instructional technique making its debut in the world of education, it has had its share of adherents, skeptics and its quota of those who are impartial or uninformed. The great divergence of opinion suggests that the attitudes in many cases may have been formed through a very limited amount of direct or indirect experience with this particular medium of instruction.

I. THE HISTORY OF PROGRAMMED INSTRUCTION

It is very difficult to be specific in discussing the origin of programmed instruction. Literature takes us as far back as 400 B.C. to point out the famed pedagogical elicitations of the Athenian marvel, Socrates. Plato's "The Meno" is replete with the nature of Socrate's method.[1] In an address at the Mid-Hudson School Board Institute Meeting, Komoski, President of the Center for Programmed Instruction, emphasized this situation by referring to a period almost two thousand years ago and reviewing the work of Quintillian whose words of advice were:

> Do not neglect the individual student. He should be questioned and praised ... he should strive for victory, yes, but it must be

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[1]Carnegie Corporation of New York, "Not from Teaching but from Questioning," Carnegie Corporation of New York Quarterly, Vol. 9, No. 4 (New York: Carnegie Corporation of New York, October, 1961), p. 1-2.

> arranged that he gains it. In this way let us draw forth his powers with both praise and rewards.[2]

In the seventeenth century Rene Descartes enunciated views from which has been borrowed the term "Cartesian Method." This method was applied to program construction for the purpose of dividing up a body of knowledge into a series of highly presentable forms. Descartes insisted that nothing be accepted until its truth is seen clearly and distinctly. To do this he advised that:

> We must divide any difficult problem into smaller and smaller parts until we come to some proposition so simple that we see its self-evident truth. We can then build on this sure basis, always proceeding by small, self-evident steps.[3]

About thirty-four years ago, Frank Laubach, an American missionary, preacher and educator, won world fame for teaching millions of illiterates how to read. His methods were very similar to those promulgated by enthusiastic supporters of programmed instruction today. Mr. Laubach in describing the techniques presented in his autobiography states that:

> We must prove to the student that he can learn easily, quickly, and delightfully, no matter how old he is. Every step must be so short that any ordinary man can take it easily. Our charts must provide for this ... for there must be no embarrassing pauses, never a question the student cannot answer, and no examination to find out what he knows ... We must keep out of the student's way--neither pushing nor retarding him. For a student is happy only when he feels free to take his natural gait ... The ordinary textbooks used in the schools of America require constant talking on the part of the teacher but our ... texts are as nearly self-teaching

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[2] P. Kenneth Komoski, "Call It Programmed Instruction Not a Teaching Machine," Mid-Hudson Channel, 10:9, January, 1961.

[3] W. T. Jones, "Rene Descartes," The World Book Encyclopedia (1962 ed.), Volume 4, 130.

> as we can make them. They require little talking by the teacher and a maximum of participation by the student.[4]

Mr. Laubach's recognition of the individuality of the learner is further illustrated with a single condensation of his principles of teaching: "Each one teach one."[5]

In 1926 and 1927 some of the principles of programmed instruction were implied in Pressey's description of a simple teaching machine.[6] The purpose of Pressey's teaching apparatus was to produce efficient practice, a basis quite in keeping with Thorndike's "Law of Effect" and "Law of Exercise" which constituted an important part of the learning theory of that day. Pressey's subsequent articles[7] included predictions of an impending revolution in education; however, his prophecies did not gain widespread recognition until Skinner's arrival on the scene in 1954. Although Pressey failed to make an adequate impression upon the educators of that day, his pioneering did serve to inspire his students into

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[4] P. Kenneth Komoski, "Programmed Instruction and Its Place in Education" (an address presented at the Annual Educational Conference sponsored by the Educational Records Bureau, New York, N.Y., 1960).

[5] Galen Saylor, "Frank Charles Laubach," The World Book Encyclopedia (1962 ed.), Volume 11, 111.

[6] Sydney L. Pressey, "A Simple Apparatus Which Gives Tests and Scores - and Teaches," School and Society, 23:373-376, March, 1926; Sydney L. Pressey, "A Machine for Automatic Teaching of Drill Material," School and Society, 24:549-552, 1927.

[7] Sydney L. Pressey, "A Third and Fourth Contribution Towards the Coming 'Industrial Revolution' of Education," School and Society, 36:668-672, November, 1932; Sydney L. Pressey, "Development and Appraisal of Devices Providing Immediate Automatic Scoring of Objective Tests and Concomitant Self-Instruction," Journal of Psychology, 29:417-447, February, 1950.

producing a considerable amount of classroom research. In addition, his work was very influential in the development of the subject matter training programs for the United States Air Force.

On March 12, 1954, Professor B. F. Skinner of Harvard University presented a penetrating account of programmed instruction before a conference on Current Trends in Psychology and Behaviour Sciences which was held at the University of Pittsburgh.[8] The thesis of Skinner's paper held that a teacher alone was an inefficient and outmoded instrument in the application of the psychological theory of learning to the process of instruction. It is difficult to determine whether it was Skinner's assertion that teachers were relatively inefficient instruments or whether it was the steadily increasing need for more education created by the tremendous growth in population and industry that made programmed instruction so appealing to a great many educators. Perhaps both factors were instrumental.

Programmed instruction as originally conceived was based on a learning theory related to the research done with animals. Its basis as outlined by some authorities naturally inherited a rigidity devoted to certain elements of behaviourist psychology. In fact it would be quite safe to conclude that over ninety percent of the programs written to date are of the Skinnerian type. The introduction of Crowder's branched programming technique was an effort to move away from Skinner's stereotype in order to utilize the principles basic to other existing theory

[8] B. F. Skinner, "The Science of Learning and the Art of Teaching," The Harvard Educational Review, 24:86-97, Spring, 1954.

of learning.

A more recent development in the movement away from the linear or Skinnerian format has been the technique of mathetical programming. Conceived by Dr. Gilbert in the late 1950's, mathetics is regarded as a decided advance in the technology of programmed instruction.[9] Mathetical programming is based on systematic subject analysis rather than the rigid format so typical of programming methods today. In describing mathetical programs Reynolds states:

> Even so, examination of most mathetical lessons to date reveals a common format: one that resembles conventional workbooks, rather than linear or branching programs. The systematic method of presentation used in mathetical lessons is referred to as the 'exercise model.' Subject matter is presented to the student at three different levels of difficulty. Each level is represented by an exercise which may vary in size from less than a page to several pages. Achieving the maximum amount of instruction per unit is the factor that determines exercise length. Within the framework of the exercise model, mathetical lessons also use branching to make allowances for differences in the abilities of students.[10]

In concluding, then, it seems reasonable to expect that future developments will consist largely of broadening the varieties of programmed techniques in an effort to accommodate specific learning objectives. One may also conclude that although programming in a certain sense has always been with us, its recognition did not achieve intensity until its effectiveness became the subject of very deliberate scrutiny through experimentation.

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[9] Robert L. Reynolds, "A Teaching Tool - for the Health Professions," NSPI Journal, 2:7, December, 1963.

[10] Ibid.

II. THE PROBLEM

Numerous questions have been asked and more are being asked about the efficacy of programmed instruction.[11] Since there is no point in education at which the evidence concerning some instructional problem is complete, it behooves the educator to derive answers based on the information that is available. It is possible, of course, for an educator to arrive at some specific conclusions by means of his own experimental work; however, it is not likely that a great deal will be accomplished with respect to the field as a whole. Furthermore, many people concerned with administering education generally do not have the time, knowledge, nor the facilities to conduct experimental investigations; consequently, they must resort to the application of the research work completed by others. Since the writer believes that very careful consideration should be given to the type of research which is to be utilized in administrative guidance, this study was designed to investigate the research done by others in order

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[11] John O. Cook and Howard G. Miller, "Programmed Learning," A Guide to Curriculum Study (Raleigh, North Carolina: Department of Curriculum Study and Research, State Board of Education, 1962), pp. 40-50; George E. Probst (ed.), Programmed Learning in the Schools: Tasks for 1962. A Summary of a Conference held by the Thomas Alva Edison Foundation and Grolier Incorporated, Albuquerque, New Mexico, January 13-14, 1962 (New York: Thomas Alva Edison Foundation, Inc., 1962),pp. 23-24; John D. Krumbholtz, "Needed Research in Programmed Instruction," Educational Leadership, October, 1963, pp. 32-33; Ruth L. Godwin, "Do We Understand the Place of Programmed Instruction in the Teaching Complex?" The ATA Magazine, 43:21-25, March, 1963; Allen Jack Edwards, "Learning Theory and Programmed Learning: Problems of Implementation," The University of Kansas Conference on Programmed Learning, Kansas Studies in Education, Vol. II, No. 2 (Lawrence, Kansas: The University of Kansas Publications, School of Education,1961), pp. 15-21.

to determine the nature of the answers to some important questions basic to the field of programmed instruction. Specifically, it was the purpose of this study to gather, to analyze and to evaluate the pertinent scientific research reports which were available to the writer through the various media listed elsewhere in the study. It was also the purpose of this study to apply this evaluation in as an objective manner as possible to the generalizations discovered and to express their utility in terms of a dependability level suitable to be considered in the administration of education.

III. ELEMENTS OF THE PROBLEM

The first element consisted of the evaluation of the available research reports in terms of an established evaluative criteria derived from the fundamentals of adequate research reporting similar to the criteria developed by Monroe and Engelhart.[12]

The second element involved the determination of answers, and the evaluation of these same answers to the questions posed in the study. The answers were determined by referring specifically to the findings of the studies that were analyzed. The evaluation consisted of the application of the results obtained in element one.

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[12]Walter S. Monroe and Max Engelhart, *A Critical Summary of Research Relating to the Teaching of Arithmetic*, Bulletin No. 58 (Urbana, Illinois: University of Illinois Press, 1931).

IV. DELIMITATIONS OF THE PROBLEM

Basically, the problem investigated by this study was delimited in two ways: (1) by the characteristics of the sources of data used, and (2) by the questions found to be most frequently asked by educators.

Characteristics of the Sources of Data

1. Generally, only investigations which were supported by universities, professional organizations and institutions, government agencies and educational systems were included in this documentary analysis.
2. Only reports of experimental investigations specifically concerned with some relevant aspect of programmed instruction were analyzed.
3. Only those research reports contributing to the formulation of conclusions pertaining to the questions posed in this investigation were considered.

Questions Which Delimited the Problem

1. Can programmed instruction be used successfully in exceptional cases? Exceptional circumstances were meant to imply conditions which ordinarily would not be handled in a "typical" classroom manner.
2. In which subject areas can programmed instruction serve successfully?
3. Can programmed instruction be used at any grade, ability or age level?

4. How effective is programmed instruction compared to traditional instruction?

5. How effective is programmed instruction compared to other instructional materials?

6. Which are the more effective and efficient means of presenting programmed materials?

7. Is the effectiveness and the efficiency of the programmed instructional materials dependent upon the type of response mode used?

8. Is feedback a necessary process in programmed instruction?

V. LIMITATIONS OF THE STUDY

The study was affected by both expected and unexpected limitations. The following list indicates the limitations of this investigation:

1. The study was limited by the success in obtaining suitable literature which reported experimental projects in the field of programmed instruction.

2. The study was limited by the amount of time which was available in which to collect and analyze the data.

3. The interpretation of the conclusions was restricted to the basic limiting assumptions which had to be made before a study of this nature could be undertaken.

VI. LIMITING ASSUMPTIONS

The nature of this evaluative study required a statement of three basic assumptions of the limiting type described by Rummel.[13]

1. It was assumed in this study that all evaluative criterion items were equally important in assessing the findings from the utilitarian point of view in educational administration. A satisfied criterion item was given a relative value of one.
2. With respect to the findings of the individual studies, it was assumed that a reliance index of 8 represented a high reliance and that any smaller number represented a low reliance.
3. It was assumed that the ratio of 0.9 or higher as determined through the application of the dependability level formula represented a high dependability level of the findings supported by one or a group of studies. A ratio below 0.9 indicated a low dependability level.

VII. TERMINOLOGY OF PROGRAMMED INSTRUCTION

As already pointed out, the principles upon which programming is based are not entirely new. However, it is only recently that programmed instruction has gained a rather widespread recognition as a

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[13] J. Francis Rummel, _An Introduction to Research Procedures in Education_ (New York: Harper & Brothers, 1958), pp. 129-130.

likely potential in the more expeditious application of the laws of learning. Glaser refers to programmed learning as a sort of applied psychology.[14] Today's critics are guilty of rigidly associating the concepts of programmed instruction with the beliefs and findings of Pressey, Skinner and Crowder. Mager, in describing a method for preparing auto-instructional programs implies that this should not be so by pointing out that:

> Other programmers approach the problem differently and assign greater or lesser weight to the steps outlined below.[15]

He goes on to emphasize that:

> -- a good program is one that works rather than one which conforms to some writing style or programming strategy.[16]

It appears that there is a need for a more specific definition that is all embracing with respect to the theory of learning. This section of the study was devoted to the presentation of the programming jargon and to the demonstration of its flexibility concerning the theory of learning. To accomplish this, each term was accompanied by the relevant theory whenever such an arrangement seemed appropriate. Several references were consulted in discussing the definitions of the terms included in this section.

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[14] Robert Glaser, "Programmed Instruction - A Behavioral View," _The American Behavioral Scientist_, November, 1962, p. 46.

[15] R. F. Mager, "A Method for Preparing Auto-Instructional Programs," _A Reprint_, p. 1. Institute of Radio Engineers, December, 1961.

[16] _Ibid_.

Programmed instruction. Previous definitions were identified rather closely with the Skinnerian concept of the learning process which depicted programmed instruction as a technique characterized by a rigidly controlled presentation of material, the elicitation of an appropriate response, guidance with respect to the subject matter and control of the way in which learning proceeds. Hilgard justifies the acceptance of Skinner's prototype on the premises that:

> Programmed instruction recognizes individual differences by beginning where the learner is and by permitting him to work at his own pace; programmed instruction requires the learner to be active; knowledge of results are available immediately; there is a continuity between the easier and the harder concepts in the organization of the program; high degree of success is guaranteed by spaced review; programmed instruction reduces anxiety because the learner is not threatened by the task.[17]

Schramm argues that the Skinnerian concept obviously does not include psychological theory other than Skinner's operant conditioning, Pavlovian conditioning or Guthrie's contiguity learning.[18] Pertaining to the various existing psychological theories of learning, recent trends in definition appear to be more flexible. Cook and Miller define programmed instruction as being:

> ... simply a rational, experimental and testable means of achieving whatever goals are desired.[19]

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[17]Ernest R. Hilgard, "What Support from the Psychology of Learning," NEA Journal, 50:20-21, November, 1961.

[18]Wilbur Schramm, Programmed Instruction Today and Tomorrow (New York: The Fund for the Advancement of Education, 1962), p. 3.

[19]John O. Cook and Howard G. Miller, "Programmed Learning," A Guide to Curriculum Study (Raleigh, North Carolina: Department of Curriculum Study and Research, State Board of Education, 1962), p. 3.

Kopstein and Shillestad consider the term programmed instruction to be synonymous with auto-instruction and state that:

> From the scientific, reductionist point of view auto-instruction is nothing but an application of the principles governing the interaction between the teaching presentation and the learning individual.[20]

In elaborating they add that:

> It is, however, a minutely systematic application of the scientific principles of learning; and the application itself is guided by the general principles of engineering design logic.[21]

In a recent issue of the NSPI Journal, Robert G. Smith, President of the National Society for Programmed Instruction, suggested that programmed instruction be defined in terms of the process of program preparation. This process would involve:

> 1. Valid and clearly defined objectives, which represent statements of the behaviour desired by the student, are developed.
>
> 2. A criterion test to evaluate the attainment of these objectives is prepared.
>
> 3. The content needed by the student so he can acquire the necessary behaviour is embedded in the appropriate media, applying known principles of instruction. This content is a program.
>
> 4. The program is tested by giving students the criterion test and revised and retested until the students reach a high level of mastery of the objectives.[22]

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[20] Ibid.

[21] Felix F. Kopstein and Isabel J. Shillestad, A Survey of Auto-Instructional Devices, ASD Technical Report 61-414 (Wright-Patterson Air Force Base, Ohio: Aeronautical Systems Command, United States Air Force, 1961), p. 33.

[22] Robert G. Smith, "President's Insights," NSPI Journal, 2:15, October, 1963.

In concluding, it seems that programmed instruction is intended to be something more than just a standardized method of presenting information to the student and making him respond to it in a desirable fashion. Its potentiality as an effective instructional technique is implied to be contingent on its flexibility to incorporate the various principles of learning. Since it includes a precise, systematic analysis of behaviour reflecting subject-matter competence, an assessment of the objectives of learning and a very careful testing in the field or laboratory, one might be quite justified in referring to it as "validated instruction."

Linear program. This is a type of program in which the sequence of items is fixed, unalterable and identical for each sequence. Sometimes this program is referred to as extrinsic because the rate and sequence of presentation are determined by the person writing the program. Because the sequence is fixed, this type of program is also called straight line, non-branching or Skinnerian. The learning theory forming the basis of this type of program is generally thought to include borrowed portions from the behavioural psychologists sometimes referred to as the associationists or members of the stimulus-response school. The development of this amalgam is highlighted by investigations of such noted personalities as Ebbinghaus, Pavlov, Thorndike, Pressey, Witaaek, Gates, Guthrie and Skinner. Skinner may be considered as representing all since he was responsible for synthesizing the relevant portions of the S-R theory promulgated by his predecessors

and applying it to a learning technique which involved active participation on the part of the learner, presentation in small steps, an abundance of repetition, immediate reinforcement of the response, knowledge of the results and maximum reduction of incorrect responses. The work of Witaaek and Gates is represented by the fact that the learner must be active. Skinner's shaping theory is implied when learning takes place in small steps. Sufficient repetition to insure overlearning represents the psychology of Ebbinghaus and Pavlov. Thorndike's "Law of Effect" is operant in the immediate reinforcement of the correct response. Providing for conditions which will minimize the number of incorrect responses utilizes Pressey's "Law of Recency." It is interesting to note that the majority of the programs being produced at present are linear in format.

Branched program.[23] Conceived by Norman Crowder, this type of program has a built-in alternate sequence of items in order to render it adaptive to the varying capabilities of the learner. The kind of response which a learner makes determines the sequence through which he will be guided. Each sequence proceeds methodically toward a given learning objective. The more knowledgeable student is permitted to omit certain frames, while the less knowledgeable is required to complete additional frames. Unlike the linear program, there is no assumption made in the branched program that the wrong

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[23]David Cram, Explaining "Teaching Machines" and Programming (San Francisco: Fearon Publishers, Inc., 1961), p. 41.

answer hinders the learning of the correct response. Rather, the purpose of the response is to guide the learner through the program. According to Crowder, the response is a measuring and a guiding device rather than a fixing device. The effects of wrong answers are presumably nullified by the way feedback is presented. The student is not merely told that he is wrong but also informed as to why he is wrong. By providing such feedback, this program satisfies the psychological theory that the learner should work at a level near to his capacity. The program also conforms to Woodworth's judicious statement that:

> In a practical situation it is probably best to start with the whole method while feeling free to concentrate on a part where something special is to be learned.[24]

Eclectic program. An eclectic program is one which has incorporated the more desirable features of both the linear and the branched formats. Logically, it should be the most effective type since its design would be accommodated by a wider range of psychological theory. No research has been conducted, however, to indicate that this is so.

Covert response. A covert response is a physically non-active response to a question in a program. It requires thinking about the answer.

Cue. This is a term used interchangeably with prompt which refers to an additional bit of information included in a program for

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[24] R. S. Woodworth, Experimental Psychology (New York: Holt, 1938), p. 223.

the purpose of ensuring the elicitation of the correct response.[25] Its inclusion in the program is justified by Pressey's "Law of Recency" which implies that the last response is the one which is remembered best. As a result, it becomes imperative that it be correct.

Cue, vanishing. A vanishing cue is a bit of information which is gradually withdrawn or eliminated entirely as the learner moves through the program.[26] It is really a part of the shaping process.

Error. In programmed instruction the error is defined as a response which is not acceptable to the programmer.[27]

Error rate. Generally, error rate refers to the percentage of incorrect responses on an item, a set of items or a whole program.[28]

Extrinsic programming. It is the process of developing a linear program in which the sequence of items determined by a programmer is unalterable. Every student must work through the same sequence.[29]

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[25]Charles I. Foltz, The World of Teaching Machines (Washington, D.C.: Electronic Teaching Laboratories, 1961), p. 67.

[26]Teaching Machine Terms: A Glossary (Bulletin 4. Hackensack, New Jersey: Universal Electronics Laboratories Corporation, 1962), p. 2.

[27]Iowa Lakeside Laboratory, Programming as a Concern to Education (Summary Report of the Eighth Okoboji Audiovisual Leadership Conference. Milford, Iowa: Iowa Lakeside Laboratory, 1962), p. 64.

[28]Ibid.

[29]Charles I. Foltz, The World of Teaching Machines (Washington, D.C.: Electronic Teaching Laboratories, 1961), p. 67.

Feedback. Feedback is that technique used in programming which provides the learner with the immediate knowledge of the suitability of his response.[30] Reinforcement of the correct response is facilitated by the process of feedback.

Frame. A frame is a step in a program. It contains information and a stimulus to which the learner responds.[31] A frame usually represents a piece of knowledge in its most comprehensible form.

Intrinsic program. This is a type of program which uses the technique of branching previously described in this list of definitions.

Item. The term item is used interchangeably with the word frame.

Confirmation. Confirmation is a built-in provision which serves as either a feedback or a reinforcing function. In this manner the learner is made aware of his progress at very frequent intervals.[32]

Novelty Effect. This is an effect produced by the human factor which influences behaviour in a new situation.[33]

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[30] *Ibid*.

[31] *Ibid*.

[32] David J. Klaus, *Job Specifications - Programmer Technician* (Pittsburgh: American Institute for Research, 1963), p. 4.

[33] Charles I. Foltz, *The World of Teaching Machines* (Washington, D. C.: Electronics Teaching Laboratories, 1961), p. 67.

Other than Popham's study, which indicated the insignificance of the Novelty Effect in invalidating research findings, no convincing evidence has been produced to determine its function in programmed learning.[34]

Dallard and Williams reminiscence effect. It is an effect which results in an increased performance of the learner immediately after the learning period has ceased. The effect is not enduring but it is important to be aware of its possible existence when designing experiments.

Overt response. An overt response refers to any physical activity involved in the learner's reaction to a stimulus contained within a program.[35]

Pace. Pace is the rate at which the student is permitted to work through the programmed material.[36]

Prompt. A prompt is a clue introduced to the program in order to make responding easier for the learner. The term is used interchangeably with cue.

Reinforcement. Reinforcement is basic to programmed learning

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[34]W. James Popham, "Novelty Effect of Programmed Instruction" (a paper presented at the first annual convention, N.S.P.I., San Antonio, Texas, March 29, 1963).

[35]Foltz, loc. cit.

[36]*Teaching Machine Terms: A Glossary*, loc. cit.

theory. It is the process of supplying feedback or information to the learner concerning the correctness of his response.[37]

Step. A step is an increment in subject matter level as the learner progresses from one item to another.[38]

Shaping. Shaping is the process of differential reinforcement of increasingly more adequate forms of behaviour until the terminal behaviour is achieved.[39]

VIII. DEFINITION OF TERMS

The following terms were pertinent to the analysis and evaluation done in this investigation:

Efficiency. Efficiency was the ratio which represented the amount learned, as measured by a criterion test, divided by the length of the learning period.

Effectiveness. Effectiveness was that quality of an instructional technique which produced learning. It was expressed in terms of the scores obtained on a criterion test independent of the length of the learning period.

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[37] Foltz, loc. cit.

[38] Teaching Machines: A Glossary, loc. cit.

[39] Ibid.

Evaluation. This term referred to the assessment of research reports on the basis of criteria which were relevant to this particular study. "Evaluation" was not synonymous with the quality of research.

Reliance index. The reliance index was the number of evaluative criterion items which were satisfied by each report that was analyzed in this study. The reliance index of each report was determined on the basis of the presence or absence of each specified item listed in the evaluative criteria. A numerical value of one was assigned to each criterion item. The maximum number of items was eight which represented the highest possible reliance index relative to one.

Dependability level. Dependability level was that quality of a conclusion or finding which was determined by the application of the dependability formula to the reliance indices that supported or did not support a conclusion or finding.

Instructional objectives. The instructional objectives included those specifically desired outcomes of learning common to most content areas. These were concept formation, development of understanding or comprehension, rote memorization, assimilation of facts, development of problem solving ability, acquisition of generalizations or principles, application of the acquired learnings, and transfer of training.

Content objectives. The objectives were statements indicating the specific subject areas in which the instructional aims were to be

achieved.

IX. REVIEW OF RELATED LITERATURE

The review of related literature was limited to a survey of descriptive reports based on documentary compilations and analyses. The similarity of design to the writer's study was considered as the criterion of relationship rather than the similarity of content material since the main body of the project included an analysis and an evaluation of most of the available literature not of the survey type. In order to emphasize the similarities and the differences between this study and others which utilized the documentary reference approach, the review of related literature included some studies outside the area of programmed instruction. All the related studies, however, were confined to the field of education.

One of the first survey type projects completed in the field of programmed instruction was a source book edited by Lumsdaine and Glaser.[40] The book was largely a compilation of research reports along with numerous articles not based on experimental evidence. It excluded any objective attempt at evaluating the conclusions and procedures which were reported.

Silberman reviewed ninety-six articles and research reports. His survey included literature dealing with the response mode, comparison of programmed instruction with the more conventional techniques,

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[40] A. A. Lumsdaine and Robert Glaser (eds.), Teaching Machines and Programmed Learning: a Source Book (Washington, D.C.: National Education Association, 1961), 310 pp.

trends in programmed instruction and the problems involved in implementing this new approach to learning. Some general statements were made; however, as in the case of Lumsdaine's and Glaser's Source Book, no effort was made to specifically evaluate the contents of the literature.[41]

Another of the more recent reviews was made by Wilbur Schramm who surveyed research concerned with several aspects of programmed instruction involving prompting, cueing, confirmation, sequence of steps, size of step, branching, reviewing, response modes and the feedback process. Again, as in most reviews within this field, the work was largely a compilation of findings in which no specific attempt was made at analyzing and evaluating the documents that were reviewed.[42]

Briggs and Angell surveyed research concerning the programming of instruction in mathematics and science. Twenty-six studies which compared programmed instruction with the conventional methods were included as part of the survey. In evaluating they concluded that:

> These studies, as a group, are not characterized by sophisticated experimental design nor by scrupulous control of extraneous variables. However, the majority of them did employ some form of statistical test to assess the significance of differences among groups on criterion test scores. Findings of "no significant differences" were reported more often than findings of significant

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[41]Harry F. Silberman, "Self-Teaching Devices and Programmed Materials," Review of Educational Research, 332:179-193, April, 1962.

[42]Wilbur Schramm, Programmed Instruction Today and Tomorrow (Washington, D.C.: Fund for the Advancement of Education, 1962), pp. 74.

difference.[43]

The remaining portion of the survey was dedicated to the review of analytical studies of the programming techniques used in mathematics and science. The purpose was to assess their significance in terms of their contributions to learning theory, value in choosing from among existing program techniques, and implications for ways to improve programmed instructions. Such factors as ability, reading skills, program revision, program format, response mode, feedback, prompting, item difficulty and sequence of items were contained in the survey. The conclusions of the study indicated (1) that programmed instruction possessed a superior efficiency over regular group methods of teaching; (2) that, in general, students were favorably disposed to the new technique; (3) that it is still uncertain which group, upper or lower, receives the greatest benefits from programmed instruction; and (4) that factors which make programmed instruction work have not been clearly identified. As in the previously mentioned studies, the assessment was more a compilation than an evaluation and involved no systematically developed criteria.

From the review of related literature, it was concluded that most studies in programmed instruction based on the review of documentary evidence were largely compilations with very little or no effort made to systematically evaluate the contents.

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[43]Leslie J. Briggs and David Angell. Programmed Instruction in Science and Mathematics. (Washington, D.C.: U.S. Office of Education, 1963), pp. 4-5. (Mimeographed.)

Documentary surveys have been made in other areas of education. Hall conducted a bibliographical review of existing theories, practices and research related to the education of gifted children. Although the review was intended to outline and evaluate the existing evidence, very little evaluation was actually presented in the study. This is emphasized in his statement that:

> Although some evaluation is submitted, a final definite statement of the truth or falsity of the theories involved in these programs and practices must await the verdict of time.[44]

In general, Hall's conclusions were based on opinion, theories and practices of others and were intended to be of value to advanced students, educators and research workers.

Marrone completed a study in which he collected, analyzed and evaluated scientific research in phonics through 1957. From the collection, he compiled accepted generalizations supported by studies which were evaluated according to a criteria developed by Monroe and Engelhart.[45] The evaluative criteria consisted of five items which were applied to each study analyzed. On this basis the studies were either accepted or rejected. Any one of the following reasons were considered ample justification for rejecting a research report:

> 1) groups were too small; 2) pupils were not representative of the total population; 3) pupil factors and non-experimental factors

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[44] Lynn Gordon Hall, "A Bibliographical Survey of the Education for Gifted Children" (unpublished Master's dissertation, University of Alberta, Edmonton, 1957), p. v.

[45] Walter S. Monroe and Max Engelhart, _A Critical Summary of Research Relating to the Teaching of Arithmetic_ (Urbana: University of Illinois, University of Illinois Press, 1931), pp. 8-11.

> were not controlled; 4) statistical procedures were inadequate; 5) methods of procedure were not clear; and 6) conclusions were not substantiated by experimental data.[46]

Even though the majority of the studies were rejected because they failed to comply with some aspect of the selected criteria, Marrone included them as evidence which supported the final conclusions based on the data provided by the accepted studies. This technique cast some doubt concerning the desirability of such abrupt labeling of the evaluated research reports. The fact that Maronne used the rejects to complement the conclusions of the acceptable studies suggested a need for a procedure which would have incorporated a scale based on some evaluative gradient.

In concluding, it was found that relatively few studies of the documentary analysis type have been made in the area of instruction. In addition, it was found that most of these studies seemed to lack objectivity in their approach to evaluation which appeared to be largely of an incidental nature.

X. DESIGN OF THE STUDY

One of the purposes of the design was to introduce some objectivity to the evaluative aspect of the study. To achieve this, the framework of the design consisted of the following elements: (1) the questions which served to delimit the study; (2) the development of

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[46]Victor Eugene Marrone, "A Critical Analysis of Scientific Research in Phonics" (unpublished Doctoral dissertation, University of Pittsburgh, Pittsburgh, 1958), pp. 17-18.

the evaluative criteria; (3) the evaluation of the individual studies in terms of the established criteria; (4) the collection of data; (5) the analysis of the data in accordance with the questions posed in the delimitation; and (6) the formation and assessment of the conclusions which served to answer the questions comprising the problem.

Questions Constituting the Problem

As already stated, the questions included were those which were considered to be most frequently asked by educators. Specifically, the development of the series of questions was an outgrowth of approximately two years of extensive reading in the field of programmed instruction. The statement of the questions was placed in that portion of the study which was concerned with the delimitations of the problem. The more specific aspects related to the questions were included in the description of the analysis of the data.

Development of the Evaluative Criteria

Each study was subjected to an evaluative criteria which was intended to determine or indicate the reliance of the results. Eight criteria were selected for purpose of evaluation. These were:

1. Duration of the experiment reported. The duration of the experiments in the field of learning was considered to be crucial in contributing to the accuracy of the findings by minimizing the effects of novelty and reminiscence. Furthermore, it was concluded that experiments of a longer duration represented more realistically the

actual or the practical learning situations to which learners are accustomed. In applying the criterion of duration, a period of three weeks was considered to be of adequate length. This meant that the time interval between the initiation and the termination of the experiment was required to be approximately three weeks in length before the criterion of duration could be judged as being satisfied.

2. Size of the samples used. The size of the sample was an important criterion item in that the N in statistical analysis represents a general population. Garrett[47] emphasized the importance of an adequate sample size when he stated that if:

> N is less than 25, say, there is often little reason for believing such small groups of persons to be adequately descriptive of any population.

He went on to point out that:

> In fact, in very small samples widely deviant scores can hardly appear in a random sample drawn from a normal group.[48]

It was on the basis of Garrett's statement that a sample of 25 was selected as the qualifying number which could satisfy the criterion of adequate sample size.

3. Reliability of the instruments used. Each study was examined for the presence of a reliability statement concerning the measuring instruments. A report of the reliability was considered to be a good

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[47] Henry E. Garrett, Statistics in Psychology and Education, (New York: Longmans, Green and Company, 1958), p. 208.

[48] Ibid.

indication that care had been exercised in the construction or the choice of the instruments. This criterion item was judged to be satisfied if a report of the reliability of the instruments was included in the study.

4. Error rate of the program. Since the programs represented the method being investigated in each case, it was considered necessary to examine them for the characteristic which revealed some reasonable degree of quality. That characteristic was concluded to be the error rate because it indicated in a very objective manner that care had been taken by means of pretesting and revising in producing an effective program. The criterion item was considered to be satisfied if a statement of the error rate was included in the report of the study under analysis.

5. Statistical analysis of the data. Statistical treatments such as the analysis of variance or the analysis of covariance are modern systematic approaches intended to provide more efficient and exact tests of experimental hypotheses. If the conclusions of the study under evaluation were based on some acceptable statistical treatment rather than on the observation of raw experimental data, then the criterion of the statistical analysis of data was considered to be satisfied.

6. Equating of the groups. Equating groups is simply a method of controlling the learner variables in order to make it possible to

determine the effectiveness of some applied treatment or condition in the process of learning. The criterion of the equivalence of groups was considered satisfied if the groups participating in the experiment were equated on the basis of ability or other characteristics regarded as variables to be controlled. The criterion was also judged to be satisfied if the statistical treatment of the data was of such a nature as to account for any observed differences between the groups.

7. Pretest relevant to the subject matter contained in the program. It was decided that to properly assess programmed instruction or some variable influencing its effectiveness or efficiency would require the determination of the achievement level of the experimental and the control subjects. Consequently, to meet the standard of the evaluative criterion required an administration of some appropriate test prior to the application of the experimental factor being investigated. In effect, the pretesting served to provide the investigator with the gain scores for statistical analysis and to equate the subjects in terms of their initial level of performance within the particular content area.

8. Definition or explanation of the terms used. The utility of experimental research depends upon the clarity of explanation. Since programmed instruction is a recent development, the inclusion of the meanings of terms was considered especially important. The criterion was satisfied if a special section of the study was devoted to the definition of terms or if the description of the experiment was

sufficiently adequate to imply the meanings.

In the development of the evaluative criteria, emphasis was placed on the rationale that even a good research project is of little value to a potential user if the important aspects of its organization are left out in the report.

The Evaluation of the Individual Studies in Terms of the Established Criteria

To facilitate the application of the evaluative criteria, each criterion item was assigned a value of one. This scheme provided for a maximum value of eight for each study that satisfied every criterion item of the list. The total number of criterion items satisfied by each study was referred to as its reliance index and represented the relative dependability value on which an educator could base his decisions. A report of a study, for instance, with a reliance index of 6 was considered to be more reliable than one which possessed an index of 4. The reliance index of each study was determined and reported in Table I, Pages 37 to 63, of the second chapter. The indices determined through the application of the criteria served as the basis in the assessment of the conclusions which resulted from the tabulation of the specific data collected through the analysis of each study.

The Collection of Data

The data used in the study were limited to experimental research projects. Only the findings and the design of each experiment reported were selected for the purpose of development of the writer's study.

The data were collected by analysis of theses, dissertations, technical reports, reports of field studies, and periodical reports. The Cameron and the Education Libraries of the University of Alberta provided the greater part of the periodicals in which a good number of the studies on programmed instruction were reported. Some of the periodicals such as the Journal of Programed Instruction, the N.S.P.I. Journal, the AID Magazine and the Automated Teaching Bulletin were obtained from the original sources because they were not available at the University Library. A small number of theses and dissertations were obtained through personal loan from the writers and through the University Interlibrary Loan Service. A considerable number of microfilm copies of the theses and dissertations were purchased from the University Microfilms Inc., Ann Arbor, Michigan. Most of the technical reports analyzed were obtained from the original sources and included such organizations as The Center for Programed Instruction, American Institute for Research, the U. S. Office of Education, the U. S. Department of Commerce, the Fund for the Advancement of Education and the Systems Development Corporation. Many reports of field studies were given to the writer by individual investigators and research departments of the large local educational systems. Although no specific technique was used in obtaining the required data, it may be concluded that correspondence and visitations to the library constituted the data collecting process. Altogether, two hundred and two studies were collected and analyzed by this survey.

Analysis of the Reports

Each report was analyzed for the purpose of obtaining the specific information which was necessary in forming the conclusions pertinent to the particular aspects of the problem. The specific data gathered were: (1) the subject field involved, (2) the instructional objectives; (3) the achievement level of the subjects; (4) the ability level of the learners, (5) the special circumstances which may have been involved, and (6) the reported findings.

Formation and Assessment of Conclusions

The data from the analysis were recorded on five by eight inch filing cards. This method permitted rapid classification and tabulation of information in accordance with the questions which delimited the study. The tabulation and classification in most cases involved the ability level of the subjects, the achievement levels, the instructional objectives, the investigator's name, the subject area, and the reliance indices. In this manner it was possible to identify specific conclusions, to determine the support they received from similar studies, and to observe the reliance indices of the supporting, opposing or neutral studies.

Each conclusion was assessed in terms of the reliance indices of the studies which supported or did not support it. If the sum of the reliance indices supporting the conclusion reached a total of eight or more, the conclusion was judged as being highly dependable. If a conclusion was supported by an indices sum that was smaller than eight, it

was judged to exist at a low dependability level. The index of eight was chosen as the standard because it represented the index of a study which satisfied all the items of the evaluative criteria. In situations where a finding was supported by some studies and opposed by others, a dependability level formula was applied in which the sum of the supporting indices was divided by the sum of the supporting and non-supporting indices. The ratio resulting from the application of this formula served as an objective and expedient expression of the degree of support that any particular finding received from the reliance indices representing the total available research dealing with that specific finding. A minimum ratio of 0.9 was required before a conclusion was assessed as highly dependable. Because a highly reliable study was one which satisfied all eight of the items of the evaluative criteria, it was necessary to set the ratio at 0.9 in order to prevent inconsistencies which would have produced by high dependability values resulting from small supporting and non-supporting indices. Briefly, the minimum ratio of 0.9 prevented a situation in which a low supporting reliance index could result in a highly dependable finding. Had a minimum ratio of 0.7 been used in lieu of 0.9, it could have been possible to achieve a high dependability level with a supporting reliance index of three and a non-supporting index of one. In this study, a reliance index of three was not considered an indication of high dependability. Briefly, the minimum ratio served in demanding a high percentage of support and also required reference to a greater number of studies in presence of contradictory evidence before a conclusion could be rated

as highly dependable.

In summary, the design comprised the evaluation of research reports and the application of the evaluative data to the assessment of the observed conclusions.

CHAPTER II

EVALUATION OF THE REPORTS AND FINDINGS

The first portion of this chapter included the evaluation of the documents from which the data were obtained. The second part was concerned with the assessment of the conclusions revealed by the tabulated data.

I. EVALUATION OF THE STUDIES

The studies from which the required information was obtained were evaluated according to an established evaluating criteria. Because it was the purpose of this study to present a detailed evaluation as well as a general picture, the results of the first evaluation were expressed in terms of the individual index numbers which represented the number of criterion items that were satisfied by each study, and in terms of the total of all the indices for each criterion item. The details of the individual evaluations were included in Table I, page 37. To facilitate tabulation, the criterion items were referred to by the following letters: (A) definition or explanation of terms, (B) size of sample, (C) duration of the experiment, (D) pretest relevant to the subject matter contained in the program, (E) reliability of the instruments, (F) error rate of the program, (G) equating of groups, and (H) statistical analysis of data.

TABLE I

EVALUATION OF RESEARCH REPORTS

Investigator[a]	Title of the research	A	B	C	D	E	F	G	H[b]	Index[c]
Alter	Retention as a Function of Length of Retention Interval	O	I	O	I	O	O	I	I	4
Alter Eigen King	The Effectiveness of Confirmation Plus Trinket Reinforcers in Young Children	O	O	O	I	I	O	I	I	4
Andrews	Programmed Instruction in Elementary School: A Study of Variables Associated with Mathematical Achievement	I	O	O	I	O	O	I	I	4
Angell	The Effect of Immediate Knowledge of Quiz Results and Final Examination Scores in Freshman Chemistry	O	I	O	I	I	O	I	O	4
Ashbaugh	The Effect upon Achievement of Written Responses to Programmed Learning Material for Students of Differing Academic Ability	O	I	O	O	I	O	I	I	4

[a]. Complete citation of each report appears in Appendix, pp. 147 - 165.

[b]. Letters referring to the individual criterion items.

[c]. Reliance index as the sum of the number of criterion items satisfied.

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Banghart McLaulin Wesson Pikaart	An Experimental Study of Programmed Versus Traditional Elementary School Mathematics	I	I	I	O	O	O	O	I	4
Banta	Attitudes Toward a Programmed Text: "An Analysis of Behaviour" Compared with "A Text of Psychology"	O	I	I	O	O	O	I	O	3
Bartz Darby	Supervised and Non-Supervised Programmed Instruction in the University Setting	O	O	I	O	O	O	O	I	2
Beane	A Comparison of Linear and Branching Techniques of Programmed Instruction in Plane Geometry	O	O	O	I	O	O	I	I	3
Belcastro	Programmed Learning: Relative Effectiveness of Four Techniques of Programming the Addition and Subtraction Axioms of Algebra	I	I	O	I	I	O	I	I	6
Bilsky	A Validation for a Learning Program for Ninth Grade	I	O	I	I	O	O	I	I	5
Birch Stuckless	Programmed Instruction and the Correction of Written Language of Adolescent Deaf Students	I	I	I	I	I	O	I	I	7

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Bivens Campbell Terry	Self-Direction in Programmed Instruction: Effects on Learning in Low Ability Students	O	O	O	O	O	O	O	I	1
Blackman Holden	Support vs. Non-Support in an Autoinstructional Word Program for Educable Retardates	I	O	O	O	O	O	I	I	3
Blank	Inquiry Training Through Programmed Instruction	O	O	O	I	I	O	I	I	4
Bokros Gelsomino	A Comparison of Two Methods for Teaching English Grammar in Ninth Grade English Classes - English 2600 vs. Conventional Method	O	I	I	I	O	O	I	I	5
Brinkmann	Educability in Visualization of Objects in Space: A Programmed Instruction Approach	O	I	I	I	I	I	I	I	7
Brown	The 1962 Tryout and Evaluation of Revised UICSM Unit I Mathematics Programs and Tests	O	I	I	O	O	O	O	O	2
Browning	Report of an Experiment in Programmed Learning with English 21 Students in Grade X of the John Oliver Secondary School	O	I	I	I	O	O	I	I	5

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Burton Goldbeck	The Effect of Response Characteristics and Multiple-Choice Alternatives on Learning During Programmed Instruction	O	O	O	O	O	O	I	I	2
Buzby Mann	The TMI Self-Tutoring Program in Spelling Compared with Teacher and Flash Card Taught Programs	O	O	I	I	O	O	I	I	4
Campbell	Bypassing as a Way of Adapting Self-Instruction Programs to Individual Differences	O	O	O	I	O	O	O	I	2
Campbell Bivens	Self-Direction in Programmed Geography Instruction	O	I	I	O	O	O	I	I	4
Cassel Ullom	A Preliminary Evaluation of an Automatic Tutoring Machine	O	O	I	I	O	O	I	I	4
Cook Spitzer	Supplementary Report: Prompting Versus Confirmation in Paired Associate Learning	O	I	O	O	O	O	O	I	2
Coulson Silberman	Effects of Three Variables in a Teaching Machine	O	O	O	I	I	O	I	I	4
Culpepper	A Comparison of Student Achievement in Two Algebra Classes Wherein Different Methods of Instruction were Used	O	O	I	I	O	O	O	I	3

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Cummings Goldstein	The Effect of Overt and Covert Responding on Two Kinds of Learning Tasks	O	I	O	O	I	O	I	I	4
Dahl	Report of Experiment with Programmed Instruction in Trigonometry Using TEMAC	O	O	O	O	O	O	I	I	2
Della-Piana Ellison Stone	Programmed Texts vs. Traditional Texts	O	I	O	I	O	I	I	I	5
Research Department, Jefferson County Schools	The Effectiveness of Programmed Instruction and Conventional Instruction in a Unit of Junior High School General Science, Motion	O	I	O	I	O	O	I	I	4
Dessart	A Study in Programmed Learning	I	O	O	I	O	I	I	I	5
Dick	Paired vs. Individual Study of Programmed Instruction in Contemporary Algebra	O	I	I	I	I	O	I	I	6
Dick Seguin	Effects of Personality Pairing on the Performance of Students in Programmed	I	I	O	I	I	O	I	O	5
Dobyns	An Experiment with Programmed Instruction in Teaching College Algebra	O	I	I	I	I	O	I	I	6

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Dodge	A Report on an Experiment in Related Technical Mathematics Involving Self Instructional Materials	O	O	I	I	O	O	I	I	4
Dorough Shapiro	Automated Instruction of Remedial English	O	I	I	I	O	O	I	I	5
Dutton	An Experimental Study in the Programming of Science Instruction for the Fourth Grade	I	I	I	I	I	O	I	I	7
Edgerton Twombly	A Programmed Course in Spelling	O	I	I	I	I	O	I	I	6
Eigen	High-School Student Reactions to Programmed Instruction	O	I	O	O	O	O	I	O	2
Eigen Filep	A Comparison of Three Modes of Presenting a Programmed Instruction Sequence	O	O	O	I	O	O	I	I	3
Eigen Komoski	Research Summary Number I	O	O	O	O	O	O	I	I	2
Eigen Margulies	Response Characteristics as a Function of Information Level	O	I	O	O	O	O	I	I	3
Ellison	A Comparison of Methods for Teaching Certain Counselling Materials	I	I	O	O	O	O	O	I	2

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Ellson Engle Barber Kempworth	Acquisition of Sight-Reading Vocabulary by Retarded Children Using Pictures as Prompt Stimuli	I	O	O	I	O	O	O	I	2
Ellson Barber	Programmed Tutoring of Elementary Reading	I	O	I	I	O	O	I	O	4
Ellson Engle Barber Kempworth	Comparison of Classroom and Programmed Learning Techniques	O	O	O	I	O	O	O	I	2
Ellson Engle Barber Kempworth	Extended Test of a Sentence Program Using Verbal Prompts	O	O	I	I	O	O	I	O	3
Ellson Engle Barber Kempworth	Comparison of Methods of Combining Classroom and Program Procedures	O	O	O	I	O	O	O	I	2
Evans Glaser Homme	An Investigation of Teaching Machine Variables Using Learning Programs in Symbolic Logic	I	O	O	O	I	I	O	I	4
Feldhusen Birt	A Study of Nine Methods of Presentation of Programmed Learning Material	O	I	O	I	O	I	I	I	5

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Ferster	The Role of Review Material in Continuous Programming with Teaching Machines	O	I	O	O	O	O	O	I	2
Ferster Sapon	An Application of Recent Developments in Psychology to Teaching of German	O	O	I	I	O	O	O	O	2
Filby Edwards	An Application of Automated Teaching Methods to Test and Teach Form Discrimination to Aphasics	O	O	O	O	O	I	O	I	2
Fillmer	Programmed Instruction in the Elementary	O	I	I	I	I	O	I	I	6
Fishell	Machine and Teachers Used in Test	O	O	O	O	O	O	I	I	2
Fry	A Study of Teaching Machine Response Modes	O	I	O	O	O	O	O	I	2
Frye	Group vs. Individual Pacing in Programmed Instruction	O	O	O	I	O	I	I	I	4
Furno	A Pilot Study in Programmed Instruction, Part I	O	I	I	O	O	O	I	I	4
Furno	A Pilot Study in Programmed Instruction, Part II	O	I	I	I	O	O	O	I	4
Furno	A Pilot Study in Programmed Instruction, Part III	O	I	I	I	O	O	I	I	5

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Gagne Dick	Learning Measures in a Self-Instructional Program in Solving Equations	0	I	0	0	0	0	0	0	1
Gavurin Donahue	Logical and Random Sequence	0	0	0	0	0	0	0	I	1
Geller	Pupils' Attitude Toward Programmed Learning	0	I	0	0	0	0	0	I	2
Glaser Reynolds Fuller	Programmed Instruction in the Intact Classroom	0	I	I	I	0	0	0	I	4
Glaser Reynolds Fuller	Programmed Instruction in the Intact Classroom	0	I	I	I	0	0	I	I	5
Goldbeck Campbell	Effects of Response Mode and Response Difficulty on Programmed Learning, Experiment 2	0	I	0	0	0	0	I	I	3
Goldbeck Campbell	Effects of Response Mode and Response Difficulty on Programmed Learning, Experiment 1	0	0	0	0	0	0	I	I	2
Goldbeck Shearer Campeau Willis	Integrating Programmed Instruction with Conventional Classroom Teaching	0	I	0	0	I	0	0	I	3
Gorow	Teaching Machine Theory Applied to Learning Statistics	0	I	0	0	0	0	I	I	3

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Gotkin Goldstein	Programmed Instruction for the Younger Learner: A Comparison of Two Presentation Modes	O	I	I	I	O	O	I	I	5
Gotkin Massa	Programmed Instruction and the Academically Gifted: The Effects of Creativity and Teacher Behaviour on Programmed Instruction with Younger Learners	O	O	I	I	O	O	I	I	4
Green Sykes	A Test of an Auto-Instructional Program on the Pharmacology of the Autonomic Nervous System	O	O	O	O	O	O	I	I	2
Green Weiss Nice	The Experimental Use of a Programmed Text in a Medical School Course	O	O	I	O	O	I	I	I	4
Greenhill Lottes Pagano	Adaptation and Evaluation of a Programmed Mathematics Course for Televised Presentation	I	I	I	I	I	O	I	I	7
Grell	Comparative Effectiveness and Efficiency of the Teaching of Spelling by Use of a Programmed Instruction Method and a Conventional Textbook Method	O	I	I	I	O	O	I	I	5

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Hatch Flint	Programmed Learning: A Comparative Evaluation of Students' Performance Variables Under Combinations of Conventional and Automated Instruction	0	0	I	0	0	0	I	I	3
Hayman Johnson	Reading and Writing Results in the Second Year of Research 1961-62	0	I	I	I	I	0	0	I	5
Heimer	The Preparation of a Program in Contemporary Algebra and a Study of its Effectiveness for Group Instruction Under Paced Conditions	I	I	I	0	I	0	0	I	5
Herrick	The Effect of Problem-Setting on Rate and Amount of Learning in Programming Teaching Machines	I	I	0	I	I	I	I	I	7
Hershberger	Cue Versus Response in Programmed Reading	0	0	0	I	0	I	I	0	3
Hershberger	Learning via Programmed Reading	0	I	0	I	0	0	I	I	4
Hessert	A Comparison of Three Methods of Programming	I	I	0	0	I	I	I	I	6
Holland	Design and Use of a Teaching Machine Program	0	0	0	0	0	0	0	0	0

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Holland Matthews	Application of Teaching Machine Concepts to Speech Pathology and Audiology	I	I	O	O	O	O	O	I	3
Holland Porter	The Influence of Repetition of Incorrectly Answered Items in a Teaching Machine Program	O	O	O	O	O	I	I	I	3
Hough	An Analysis of Efficiency and Effectiveness of Selected Aspects of Machine Instruction	O	O	I	I	I	O	I	I	5
Hough Revsin	Programmed Instruction at the College Level: A Study of Several Factors Influencing Learning	O	I	I	I	I	I	I	I	7
HRB-Singer, Inc.	Star-Political Science Department, Penn State Research Report	O	I	I	I	O	O	I	O	4
Huffman	Programmed Business Mathematics	O	I	I	I	I	O	O	O	4
Hughes	The Effectiveness of Programmed Instruction: Experimental Findings for 7070 Training	O	I	I	O	O	O	I	I	4
Hughes McNamara	A Comparative Study of Programmed and Conventional Instruction in Industry	O	I	O	O	O	O	I	I	3

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
International Correspondence Schools	The PL-100 Experiment	I	I	O	O	O	O	O	O	2
Jacobs	An Evaluation of a Programmed Course in Vocabulary Development in Cincinnati Public Schools, 1962-1963	O	I	I	O	O	O	I	I	4
Jacobs	The Influence of Teaching Machine Procedure upon Learning High School Chemistry	O	O	O	I	I	O	I	I	4
Joos	Utilization of Teaching Machine Concept in Elementary School Arithmetic	O	I	I	I	O	O	I	I	5
Kalin	The Use of Programmed Instruction in Teaching an Advanced Mathematical Topic	O	I	O	I	O	O	O	I	3
Kalk	Experimental Analysis of Self-Instructional Device Variables with Mentally	I	O	O	O	O	O	I	I	3
Keislar	The development of Understanding in Arithmetic by a Teaching Machine	O	O	O	I	O	O	I	I	3
Keislar McNeil	A Comparison of Two Response Modes in an Auto-Instructional Program with Children in Primary Grades	O	I	I	I	I	I	I	I	7

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
Kletter	Programmed Learning: An Experimental Investigation	O	I	I	O	O	O	I	O	3
Knirk	Halogen Family Program Evaluation	O	I	O	O	O	O	I	I	3
Knudson	Effectiveness of Overt, Covert and Reading Response Modes in Programmed Instruction	I	I	O	I	I	I	I	I	7
Krumbholtz Bonawitz	The Effect of Receiving the Confirming Response in Context in Programmed Materials	O	O	O	O	O	O	O	I	1
Krumbholtz Weisman	The Effect of Overt versus Covert Responding to Programmed Instruction on Immediate and Delayed Retention	O	O	O	O	I	I	O	I	3
Krumbholtz Weisman	The Effect of Intermittent Confirmation in Programmed Instruction	O	O	O	O	I	I	I	I	4
Kunkel	An Experiment with Teaching Machines in Classrooms for the Educable Mentally Retarded	I	O	I	I	O	O	I	I	5
Lambert	Experimental Folklore and Experimentation: A Study of Programmed Learning in the Wauwatosa Public Schools	O	O	O	I	O	O	I	I	3

TABLE I (continued)

Investigator	Title of Research	A	B	C	D	E	F	G	H	Index
Lane	An Experiment with Programmed Instruction as a Supplement to Teaching College Mathematics by Closed Circuit Television	O	O	I	O	I	O	I	I	4
Legg	Programmed Instruction and Lecture-Discussion Methods Compared for Effectiveness in Teaching Agricultural Finance to Vocational Agricultural Students	I	I	O	I	O	I	I	I	6
Levin Baker	Item Scrambling in a Self-Instructional Program	O	O	I	I	I	O	I	I	5
Lombard	An Experimental Study in Algebra I: A Comparison of the Effectiveness of TEMAC Algebra I Programmed Materials and Conventional Techniques	O	I	I	I	O	O	I	I	5
Lottes Palmer Oakes	An Experimental Comparison of Differential Rates of Pacing Programmed Mathematics	O	I	O	I	I	O	I	I	5
Maisor	A Study of the Effectiveness of a Programmed Unit on the Hysteria Syndrome in Three Colleges	I	O	O	O	O	O	I	I	3
Malpass	Comparison of Two Automated Teaching Procedures for Retarded Children	O	O	I	I	O	I	I	I	5

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
McDonald Allen	An Investigation of Presentation, Response, and Correction Factors in Programmed Instruction	O	I	O	I	I	O	O	I	4
McGarvey	Programmed Instruction in Ninth Grade Algebra	O	O	I	I	O	O	O	O	2
McLaulin	An Investigation of the Application of Programmed Learning Concepts to Elementary School Arithmetic	O	I	I	I	O	O	I	I	5
Melaragno	Effect of Negative Reinforcement in an Automated Teaching Setting	O	O	O	O	O	O	I	I	2
Melaragno Silberman Coulson	A Comparison of Fixed Sequence and Optional Branching Auto-Instructional Methods	O	O	O	O	I	O	I	I	3
Memmot	The Effectiveness of Three Methods of Programming and Their Relationship to Achievement	O	O	O	I	O	O	I	I	3
Meyer	Report on the Initial Test of a Junior High School Vocabulary	O	O	O	I	O	O	I	I	3
Miller	An Experimental Study of the Effects of Programmed Instruction on English Punctuation Skills	O	I	O	O	I	O	I	I	4

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
Moore Smith	Knowledge of Results in Self-Teaching Spelling, Experiment I	0	I	0	I	0	0	0	0	2
Moore Smith	Knowledge of Results in Self-Teaching Spelling, Experiment II	0	0	I	I	0	0	I	I	4
Moore Smith	Knowledge of Results in Self-Teaching Spelling, Experiment III	0	0	0	0	0	0	I	I	2
Moore Smith	The Role of Knowledge of Results in Programmed Instruction	0	0	I	0	0	0	0	I	2
Moses	A Comparison of the Results of Achievement with Programmed Learning and Traditional Classroom Techniques in First Year Algebra at Spring Branch Junior High School	0	I	I	0	0	0	I	0	3
Naumann	A Laboratory Experience in Programed Learning for Students in Educational Psychology	0	I	I	0	0	0	0	0	2
Naumann	Development of an Automated Basic Spelling Program for Educable Handicapped Children	0	0	0	I	0	0	0	0	1

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
Northcutt	The Comparative Effectiveness of Classroom and Programmed Instruction in Teaching of Decimals to Fifty Grade Children	O	I	I	I	I	O	I	I	6
Oakes	Use of Teaching Machines as a Study Aid in Introductory Psychology Course	O	I	O	O	O	O	O	I	2
O'Hare	Teaching Algebra to Ninth and Tenth Grade Pupils with the Use of Programmed Materials and Teaching Machines	I	I	I	I	O	O	I	I	6
O'Hare	Teaching Spelling to Third and Fourth Grade Pupils with the Use of Programmed Materials and Teaching Machines	O	I	I	I	O	O	I	I	5
O'Hare	A Consideration of Teaching Machines and Programmed Materials with Individualized Student Programs in a Small Group	O	O	O	O	O	O	O	O	0
O'Toole	A Study of Elementary School Staff and Student Attitudes Toward a Semi-Automated Instructional Program in Spelling	I	I	I	I	O	O	O	I	5

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
Peck	An Evaluation of a Pilot Class Using Programmed Algebra	O	I	I	O	I	O	I	I	5
Pikaart	A Factor Analytic Study of Success in Programmed Textbook Instruction in Elementary School Arithmetic	O	I	I	I	I	O	O	I	5
Pinkerton Hay	A Study of the Feasibility of Using Programmed Instruction in Teaching Business Communications	I	I	I	I	O	O	I	I	6
Porter	Spelling Taught by Machine: An Application of Reinforcement Psychology to Classroom Teaching	O	O	I	I	O	O	O	I	3
Price	Automated Teaching Programs with Mentally Retarded Students	O	O	I	I	O	O	I	I	4
Programed Learning Committee	An Experimental Test of TEMAC Text by F. Lawvere - The Language of Algebra: Fields and Ordered Fields	O	I	I	I	O	O	O	I	4
Raygor Wark	Reading Skills Project of University of Minnesota Undertakes Study	O	I	O	O	O	O	O	I	2
Rea Gray	Teaching Parliamentary Procedure Through Programmed Instruction	O	I	O	I	O	O	O	I	3

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
Reed Hayman	An Experiment Involving Use of English 2600, An Automated Instruction Text	O	I	I	I	O	O	I	I	5
Research Department	A Pilot Study of Pupils' Learning of Grammar and Usage Through a Programmed Text-book	O	O	I	I	O	O	I	I	4
Reynolds Glaser	Repetition and Spaced Review in the Learning of Connected Discourse	O	O	O	I	O	O	I	I	3
Ripple	A Comparison of the Effective-ness of a Programmed Text with Three Other Methods of Presentation	O	I	O	O	I	I	I	I	5
Robinson Lerbinger	Subjective Reactions of Students to a Programmed Work-book for a Continental Class-room Course	O	I	O	I	O	O	O	O	2
Roe	Automated Teaching Methods Using Linear Methods	O	I	O	O	O	O	I	I	3
Roe	A Comparison of Branching Methods for Programmed Learning	I	O	O	I	O	O	I	I	4
Roe Case Roe	Scrambled versus Ordered Sequence in Autoinstructional Programs	O	O	O	O	O	O	I	I	2

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
Rothkopf	Automated Teaching Devices and a Comparison of Two Variations of the Method of Adjusted Learning	O	O	I	I	O	O	I	I	4
Rothkopf	Programmed Self-Instructional Booklets, Mnemonic Phrases and Unguided Study in Acquisition of Equivalences	O	I	O	I	O	O	O	I	3
Ruehl	An Experiment in the Use of an Auto-Instructional Aid in Teaching Electricity	I	I	I	I	I	O	I	I	7
Rushton	Roanoke Experiment	O	I	I	O	O	O	O	O	2
Schutz Baker Gerlach	Teaching Capitalization with a Programmed Text	O	O	O	I	O	O	I	I	3
Selmeier	Observation on the Results of the TEMAC First Year Algebra Program	O	I	O	I	O	O	I	I	4
Shay	Relationship of Intelligence to Step Size on a Teaching Machine Program	O	I	O	I	I	I	I	I	6
Shearer	Long-Term Retention of Social Science Material Presented by Programmed and Conventional Methods	O	O	O	I	O	O	I	I	3

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Silberman Melaragno Coulson	Confirmation and Prompting with Connected Discourse Material	O	O	O	O	I	O	O	I	2
Silverman Alter	Note on the Response in Teaching Machine Programs	O	I	O	O	O	O	O	O	1
Silverman Alter	Response Mode, Pacing and Motivational Effects in Teaching Machines, Experiment I	O	O	O	I	O	O	I	I	3
Silverman Alter	Response Mode, Pacing and Motivational Effects in Teaching Machines, Experiment II A	O	O	O	I	O	O	I	I	3
Silverman Alter	Response Mode, Pacing and Motivational Effects in Teaching Machines, Experiment II B	O	O	O	I	I	O	O	I	3
Silverman Alter	Response Mode, Pacing and Motivational Effects in Teaching Machines, Experiment III	O	O	O	I	O	O	I	I	3
Silverman Alter	Response Mode, Pacing and Motivational Effects in Teaching Machines, Experiment IV	O	O	O	I	O	O	O	I	2

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Smith Quackenbush	Devereux Teaching Aids Employed in Presenting Elementary Mathematics in a Special Education Setting	O	I	I	I	O	O	I	I	5
Smith	Medical Terminology ... P I Cuts Training Time	O	I	I	O	O	O	I	O	3
Smith	The Teaching of Elementary Statistics by Conventional Classroom Method Versus the Method of Programmed Instruction	I	I	O	O	I	O	I	I	5
Smith Moore	Size-of-Step and Achievement in Programmed Spelling	O	O	I	I	O	I	O	I	4
Spencer	Comparison of Televised with Teaching Machine and Televised with Instructor Presentations of English Grammar	O	O	I	I	I	O	I	I	5
Stanton	Effectiveness of a Programmed Text on the Retention of English at the Ninth Grade Level	I	I	I	I	O	O	I	I	6
Stevens	An Experiment in Programmed Learning During the Summer Session	O	O	I	I	O	O	I	I	4

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Stolurow	Programmed Instruction for the Mentally Retarded	0	0	0	I	0	0	0	I	2
Stolurow Walker	A Comparison of Overt and Covert Response in Programmed Learning	0	0	0	I	0	0	I	I	3
Stolurow Lippert	Prompting, Confirmation and Vanishing in Teaching of a Sight Vocabulary	I	0	0	0	0	0	I	I	3
Stone	The Effects of Learner Characteristics on Performance in Programmed Text and Conventional Text Formats	0	I	0	I	I	I	I	I	6
Stone	An Experiment in Programmed Learning	0	I	I	I	0	0	I	I	5
Sullivan	An Investigation of the Effectiveness of Programmed Instruction in Mathematics in Four Pasadena Secondary Schools	0	I	I	0	0	0	0	I	3
Tobias Weiner	Effect of Response Mode on Immediate and Delayed Recall from Programmed Materials	0	0	0	I	I	I	0	I	4
Tohtz	Out-of-Class Programmed Instruction Compared with Conventional Homework Assignments in Teaching Expository Writing in Freshman English	I	I	I	I	0	0	0	0	4

TABLE I (continued)

Investigator	Title of the Research	A	B	C	D	E	F	G	H	Index
Trittipoe Trittipoe Hahn	The Effectiveness of Three Programed-Learning Frame Styles	0	0	0	0	0	0	I	I	2
Troemel	What Research Shows About Programmed Learning and Remedial Readers	0	I	I	I	0	0	0	I	4
Tully Burnette	Immediate Learning Outcomes and Transfer Associated with Programed Instruction and Traditional Teaching	0	0	0	I	0	0	I	I	3
Unruh	An Investigation of Four Methods of Presenting Programmed Material	I	0	0	I	I	0	I	I	5
Waddick	A Study of the Relative Efficacy of Programed Material and Conventional Approaches in Teaching of English Vocabulary	0	0	I	I	0	0	I	I	4
Wahler	A Selective Reference System	0	0	0	I	0	0	0	0	1
Waldrip	A Study of the Effectiveness of the English 2600 Programmed Text in Grade Nine	0	I	I	I	0	0	0	I	4
Wendt Rust	Pictorial and Performance Frames in Branching Programmed Instruction	0	I	I	I	I	I	0	I	6

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Wesson	An Experimental Evaluation of Selected Methods for Employing Programmed Textbook Materials in Elementary School Arithmetic	0	I	I	I	0	0	I	I	5
Whitlock Copeland Craig	Programming Versus Independent Study in Learning Elementary Statistics	0	0	0	0	0	0	I	I	2
Williams	Comparison of Several Response Modes in a Review Program	0	0	0	0	0	0	I	I	2
Winskill	Report of an Experiment in Programmed Learning, Grade 9, Vancouver Technical School, January 14, 1963 to June 14, 1963.	0	I	I	I	0	0	I	I	5
Wittrock	Response Mode in the Programing of Kinetic Molecular Theory Concepts	0	I	0	0	0	0	I	I	3
Wood	Programmed Textual Material as a Partial Substitute for Teacher-Led Classroom Procedures in Geography	0	I	0	0	I	I	I	I	5
Woods	Development of an Automated Basic Spelling Program for Retarded Children	I	0	I	I	0	0	0	0	3

TABLE I (continued)

Investigator	Title of the research	A	B	C	D	E	F	G	H	Index
Wriggle Hite	The Amount and Nature of Teacher Help Necessary for Optimum Achievement Through the Use of Programmed Learning Material	O	I	I	I	O	O	I	I	5
Wurtz	Teaching Machine for Driver Education	O	I	O	I	O	O	I	O	3
Yarmey	Overt and Covert Responding in Programmed Learning	O	O	O	I	O	O	I	I	3
Zabka	A Field Study Contrasting Programmed Instruction and the Traditional Classroom Presentation in Grades Seven and Eight	I	I	I	I	O	I	I	I	7

Observation of Table II, page 65, revealed a number of characteristics of the surveyed literature. Only 14 percent of the available literature reported error rates of the programs which were used in the experiments. Since this finding suggested that the remaining studies used programs which may or may not have been carefully constructed, there was no basis on which to assume that research in general utilized pretested programs in determining the effectiveness of the various aspects of programmed instruction. Definitions or explanations of terms, factors crucial to the proper interpretation of the findings, appeared in only 18 percent of the studies analyzed. It seemed in most cases that the literature assumed only one meaning per term and that the reader was aware of this assumption. Statements of the reliability of the instruments used were made in only 26 percent of the studies. It was apparent that in many instances the investigators assumed that the reliability was adequate because standardized instruments were used in measuring the effects of the variables being investigated. Only 45 percent of the studies involved durations of time equal to or exceeding the minimum of three weeks as required by the criteria. An adequate sample of 25 or more was achieved in 54 percent of the experiments, that is, only slightly more than half of the groups used were considered to be adequately representative of the population from which they were presumably chosen. Pretesting to determine the initial performance level of the subjects was done in 63 percent of the studies. Other investigations assumed that the initial performance level of the groups was either equal for all groups or not seriously different because of

TABLE II

TOTAL AND PERCENTAGE OF STUDIES SATISFYING EACH ITEM OF THE EVALUATIVE CRITERIA

Criterion Item	Total[a]	Percentages[b]
Definition or explanation of terms	35	18%
Size of the sample used	108	54%
Duration of the experiment	89	45%
Pretesting to determine initial performance level	125	63%
Reliability of the measuring instruments	51	26%
Error rate of the program	27	14%
Equating of groups	138	69%
Statistical analysis of data	172	86%

[a] Total of studies satisfying each item of the evaluative criteria.

[b] Percentage of studies satisfying each item of the evaluative criteria.

the type of statistical treatment used. In 31 percent of the studies analyzed no attempt had been made to account for any differences between the groups. In most cases the groups were assumed to be sufficiently equivalent with respect to the various learner variables. The most adequate performance in reporting involved the statistical analysis of data. Eighty - six percent of the reports indicated that some acceptable approach had been used in the interpretation of the data. In summarizing, it was concluded that the evaluation of the reports revealed major weaknesses with respect to the explanation of the terms, duration of the experiments, reliability of the instruments used and the description of the programs in terms of the error rate. The two somewhat less serious weaknesses were found to be the size of the samples used and the lack of pretesting to determine the initial level of performance.

II. THE FINDINGS AND THEIR EVALUATION

To identify and evaluate the specific findings related to the questions posed in the delimitation, tables were so constructed as to include the supporting, the non-supporting and the opposing indices along with the data gathered during the analysis. In this manner it was possible to reveal the specific findings and at the same time to assess their dependability by applying the dependability formula to reliance indices of the supporting literature.

Programmed Instruction and the Exceptional Cases

After examining the literature gathered for this report, it was

found that very few studies were concerned with the comparison of programmed instruction and the conventional techniques in situations differing from what would be expected within a normal classroom. A portion of the studies dealing with special cases involved comparisons of the effectiveness of program characteristics. These reports were included in the more appropriate sections of this study.

Observation of Table III indicated that the data gathered was insufficient to reveal more than one specific finding which possessed a high level of dependability. This finding showed that teaching the recognition of words in spelling or reading to retarded pupils by means of programmed instruction was at least as effective as teaching the same material through the use of the more conventional techniques. From the more general point of view it appeared that programmed instruction was at least as effective as conventional procedures with some tendency toward being superior. This indication was supported by the fact that no study was reported in which the conventional methods were found to be more effective.

Programmed Instruction Within the Various Subject Fields

Although a considerable number of investigations were concerned with the effectiveness and efficiency of programmed instruction as compared to the conventional methods, this abundance of research has been restricted to a surprizingly limited number of subject areas. The greatest portion of the studies were conducted within the fields of mathematics, physical science, English, and psychology.

TABLE III

RESEARCH REPORTS COMPARING THE EFFECTIVENESS OF PROGRAMMED INSTRUCTION WITH CONVENTIONAL METHODS IN EXCEPTIONAL CASES

Investigation	Exceptional Case	Subject Area	Instructional Objectives	PI[a]	NI[b]	CI[c]
Blackman Smith	Educable retarded	Reading and	Word perception Comprehension		5	
		Arithmetic	Concepts Understandings Problem solving		5	
Birch Stuckless	Adolescent deaf	Grammar and Composition	Concepts Application	7		
Ellson Engle Barber Kempworth	Retarded children	Sight reading	Memorization Comprehension	2		

[a] Reliance indices supporting programmed instruction

[b] Neutral reliance indices

[c] Reliance indices supporting the conventional methods

TABLE III (continued)

Investigation	Exceptional Case	Subject Area	Instructional Objectives	PI	NI	CI
Filby	Severely damaged aphasics	Not specified	Form discrimination		2	
Malpass Gilmore Hardy Williams	Educable mentally handicapped	Reading Spelling	Word recognition	5		
Kunkel	Retarded children	Spelling	Memorization Recognition	5		

Programmed instruction in mathematics. Specific conclusions in this section were derived from a set of figures based on Table IV, page 71. Each figure was designed to represent the findings in terms of: (1) the specific content area, (2) the achievement level of the experimental and control groups, (3) the ability level of the learners, (4) the instructional objectives and (5) the reliance indices of the supporting, opposing or the neutral studies. Only those findings which rated high in dependability were referred to in this portion of the study.

Although there was a tendency to favor programmed instruction in mathematics at the elementary level, only one finding was rated as highly dependable. It revealed that programmed instruction was equally effective to conventional methods in teaching problem solving in mathematics to average ability groups at the elementary school level. Figure 1, page 76, represents the summary and evaluation of the findings.

An even greater tendency was found to favor programmed instruction at the junior high school level. In fact, only one of the available studies supported conventional instruction as being superior to programmed instruction. However, in spite of all the evidence supporting programmed instruction, only one specific finding was rated as being highly dependable. It indicated that programmed instruction was equally effective to conventional instruction in teaching or in attaining unspecified learning objectives at the junior high school level involving heterogeneous ability groups. Figure 2, page 77,

TABLE IV

RESEARCH COMPARING THE EFFECTIVENESS
OF PROGRAMMED INSTRUCTION WITH CONVENTIONAL
METHODS IN MATHEMATICS

Investigation	Achievement level	Ability level	Instructional objectives	PI[a]	NI[b]	CI[c]
Banghart	Elementary Grade 4	Range of abilities	Comprehension Problem solving	5	5	
Bartz	College	Not specified	Not specified		2	
Beane	Senior High School	High Low	Concepts Principles		5	
Brinkman	Junior High School Grade 8	Range of abilities	Transfer Problem solving	5		
Brown	Junior High School Grade 9	Range of abilities	Principles Skills Concepts		2	
Dessart	Junior High School Grade 8	Superior	Concepts Understandings Transfer		5	

[a] Indices favoring programmed instruction
[b] Neutral indices
[c] Indices supporting conventional instruction

TABLE IV (continued)

Investigation	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Dick	College freshmen	Not specified	Transfer Concepts Understanding		5	
Dobyns	College	Range of abilities	Not specified		6	
Dodge	Technical school	Range of abilities	Skills Comprehension Problem solving		4	
Feldhusen	Junior High School Grade 7	Mixed abilities Average	Skills Concepts		5	
Fishell	Junior High School Grade 9	Range of abilities	Not specified	2		
Furno Part I	Junior High School Grade 9	Range of abilities	Not specified		4	
Furno Part II	Junior High School Grade 9	Not specified	Not specified		4	
Furno Part III	Junior High School Grade 9	Range of abilities	Not specified	5		

TABLE IV (continued)

Investigation	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Glaser Fuller	Junior High School Grade 9	High ability Average	Not specified	5		
Glaser Reynolds Fuller	Elementary Grade 1	Range of abilities	Skills (facts)		4	
Gorow	College	Not specified	Concepts Transfer Problem solving Understandings		3	
Heimer	College freshmen	Not specified	Concepts Problem solving		5	
Huffman	Post-High School	Not specified	Not specified	4		
International Correspondence Schools	Not specified	Not specified	Facts Concepts		2	
Joos	Elementary Grades 4 and 5	Low Average High	Computation Problem solving		5	
Kalin	Elementary Grades 4, 5 and 6	Superior	Conceptual understanding		3	

TABLE IV (continued)

Investigation	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Kletter	Junior High School Grade 9	Range of abilities	Not specified		5	
Lane	College	Range of abilities	Concepts	4		
Lombard	Senior High School	Average Below average	Not specified		5	
McGarvey	Junior High School Grade 9	Range of abilities	Not specified	2		
McLaulin	Elementary	Average	Comprehension Problem solving	5		
Moses	Junior High School	Low High	Not specified		3	
Northcutt	Elementary Grade 5	Range of abilities	Skills Facts Concepts Application			6
O'Hare	Junior High School Grade 9	Not specified	Not specified		5	
Pikaart	Elementary Grade 4	Range of abilities	Problem solving	5		
			Computation		5	

TABLE IV (continued)

Investigation	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Programed Learning Committee	College	Not specified	Not specified			4
Rushton	Junior High School Grade 9	Range of abilities	Not specified	2		
Selmeier	Senior High School Grade 10	Average Above average	Not specified			4
Smith	College	Not specified	Not specified		5	
Sullivan	Secondary	Range of abilities	Not specified		3	
Tully	College	Range of abilities	Concepts Principles Transfer		3	
Wesson	Elementary Grade 4	Range of abilities	Not specified		5	
Whitlock	College	Not specified	Not specified	2		

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts											4	6
Concepts		3										6
Principles												
Understandings		3		5						5		
Application		5		5	5			5		5	5	6
Transfer												
Not specified										2		

FIGURE 1

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN MATHEMATICS AT THE ELEMENTARY LEVEL

[a] Reliance indices favoring programmed instruction

[b] Neutral reliance indices

[c] Reliance indices favoring conventional instruction

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts											7	
Concepts		5									7	
Principles											2	
Understandings		5										
Application										5		
Transfer		5								5		
Not specified	5					5				11	19	

FIGURE 2

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN MATHEMATICS AT THE JUNIOR HIGH SCHOOL LEVEL

[a] Reliance indices which favor programmed instruction

[b] Neutral reliance indices

[c] Reliance indices favoring conventional instruction

summarizes the findings and their evaluation.

Out of the eight specific findings indicated in Figure 3, page 79, not one was rated as highly dependable, although the general trend seemed to indicate that programmed instruction and conventional techniques were equally effective in teaching mathematics at the senior high school level. Figure 3 also suggested that actually very little has been done with programmed instruction in mathematics at the high school level.

Figure 4, page 80, implied that perhaps programmed instruction in mathematics could be most successful in comparison to the conventional methods at the college level. Except for one specific case, all the findings implying that programmed instruction was at least as effective as the traditional methods were rated as highly dependable. Briefly, the findings indicated that programmed instruction was equally effective to conventional techniques in teaching concepts, understandings, application of things learned, and transfer in mathematics at the college level. Since no attempt was made in any of the studies to deal with different ability levels, it was assumed that the college level was synonymous with at least the average ability level. In numerous cases the instructional objectives were not specified. These studies, however, supported the specific findings at the high level of dependability.

Programmed instruction in English. Table V, page 81, includes the available studies which compared programmed instruction to

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts												
Concepts		5						5				
Principles		5						5				
Understandings												
Application												
Transfer												
Not specified			4		5	4		5			3	

FIGURE 3

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN MATHEMATICS AT THE SENIOR HIGH SCHOOL LEVEL

[a] Reliance indices favoring programmed instruction

[b] Neutral reliance indices

[c] Reliance indices favoring conventional instruction

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts												
Concepts										4	16	
Principles											3	
Understandings											8	
Application											8	
Transfer											11	
Unspecified										4	15	4

FIGURE 4

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN MATHEMATICS AT THE COLLEGE LEVEL

[a] Reliance indices favoring programmed instruction

[b] Neutral reliance indices

[c] Reliance indices favoring conventional instruction

TABLE V

RESEARCH COMPARING THE EFFECTIVENESS OF PROGRAMMED INSTRUCTION WITH CONVENTIONAL METHODS IN ENGLISH

Investigation	Achievement level	Ability level	Instructional objectives	PI[a]	NI[b]	CI[c]
Bilsky	Junior High School Grade 9	High Average Low	Unspecified			5
Bokros Gelsomino	Junior High School Grade 9	Average	Concepts Application	5		
Browning	Senior High School Grade 10	Below average	Unspecified		5	
Buzby Mann	Elementary Grade 4	Accelerated Average Slow	Concepts Application		4	
Dorough Shapiro	College	Unspecified	Unspecified		5	

[a] Reliance indices supporting programmed instruction

[b] Reliance indices which are neutral

[c] Reliance indices supporting conventional instruction

TABLE V (continued)

Investigation	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Edgerton Twombly	Elementary Grade 3	Average	Principles Concepts Application Facts	6		
Ellson Barber	Elementary	Unspecified	Facts Comprehension	4		
Fillmer	Elementary Grade 4	Low Average High	Unspecified		6	
Gotkin Massa	Elementary Grades 4 and 5	High	Skills Concepts Application		4	
Grell	Elementary Grade 4	Average	Unspecified		5	
Jacobs	Junior High School Grades 7, 8, and 9	Mixed abilities	Transfer Facts		4	4
Miller	Senior High School Grades 10 and 11	High Average Low	Acquisition Transfer	4		
O'Hare	Elementary Grades 3 and 4	Average	Comprehension Transfer Memorization		5	

TABLE V (continued)

Investigation	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Porter	Elementary Grade 6	Mixed abilities	Transfer Others not specified		3	
Rea	College	Unspecified	Understanding Transfer	3		
Reed Hayman	Senior High School Grade 10	High Average Low	Unspecified Unspecified Unspecified	5 5	 5 	
Research department	Junior High School Grade 8	Low Average High	Unspecified Transfer	4	 4	
Spencer	College	Unspecified	Unspecified		5	
Stanton	Junior High School Grade 9	Mixed abilities	Unspecified	6		
Stone	Junior High School Grade 9	Unspecified	Unspecified		6	
Waddick	Junior High School Grade 9	High Average Low	Facts Concepts Understandings Transfer			4
Wahler	Senior High School Grade 10	Average Below Average	Unspecified	1		

TABLE V (continued)

Investigation	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Waldrip	Junior High School Grade 9	Mixed abilities	Facts Concepts Understandings Application		4	
Winskill	Junior High School Grade 9	Mixed abilities	Understanding		5	
Zabka	Junior High School Grades 7 and 8	Low Average High	Unspecified		7	

conventional instruction in English at the elementary, junior high school, senior high school and the college levels. Figures based on the data found in this table were constructed for the purpose of revealing the findings and their level of dependability in a specific manner.

At the elementary level four high level conclusions were identified by Figure 5, page 86. These were: programmed instruction and conventional methods are equally effective in teaching concepts to high ability groups, programmed instruction and conventional instruction are equally effective in teaching facts to average groups, the two methods are equally effective in teaching concepts to average ability groups and programmed instruction and conventional methods are equally effective in teaching unspecified learning material to average ability groups. No study was found to support conventional instruction as a superior method to programmed techniques.

At the junior high school level Figure 6, page 87, showed that: programmed instruction and conventional instruction are equally effective in teaching understanding to mixed ability groups and that the two methods are also equally effective in achieving unspecified learning objectives with the mixed ability groups. A general tendency to favor conventional instruction at the three ability levels was noted, however, none of the specific findings supporting traditional methods existed at the high dependability level.

At the senior high school level three highly dependable findings were identified by Figure 7, page 88. Programmed instruction was found

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts				6	5					4		
Concepts		8		6	5			4				
Principles				6								
Understanding					5					4		
Application		4		6								
Transfer					5						3	
Unspecified		6			11			6			3	

FIGURE 5

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN ENGLISH AT THE ELEMENTARY LEVEL

[a] Reliance indices supporting programmed instruction

[b] Neutral reliance indices

[c] Reliance indices supporting conventional instruction

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts			4			4			4		4	4
Concepts		4	5			4			4		4	
Principles												
Understandings			4			4			4		9	
Application				5							4	
Transfer	4		4	4		4	4		4		4	
Unspecified	4	7	5	4	7	5	4	7	5	6	6	

FIGURE 6

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN ENGLISH AT THE JUNIOR HIGH SCHOOL LEVEL

[a] Reliance indices favoring programmed instruction

[b] Reliance indices which are neutral

[c] Reliance indices favoring conventional instruction

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts												
Concepts												
Principles												
Understandings												
Application												
Transfer	4			4			4					
Unspecified	9			5	5		10	5				

FIGURE 7

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN ENGLISH AT THE SENIOR HIGH SCHOOL LEVEL

[a] Reliance indices favoring programmed instruction

[b] Reliance indices which are neutral

[c] Reliance indices favoring conventional instruction

to be equally effective to conventional instruction in achieving unspecified learning objectives at the average ability level. Programmed instruction was found to be more effective than conventional methods in achieving unspecified learning objectives at the high ability level. The two methods were found to be equally effective in producing learning at the low ability level. It is doubtful if any findings would have been rated as highly dependable if the instructional objectives had been specified. The studies generally tended to support programmed instruction as the more effective method of instruction.

Figure 8, page 90, revealed one high level finding at the college level. It indicated that programmed instruction and the conventional methods were equally effective in achieving unspecified learning objectives at the mixed ability level. Here, again, it is very unlikely that any finding would have been rated highly had the abilities and the instructional purposes been specified. No evidence was found to support conventional instruction as a better method.

Programmed instruction in science. Examination of Table VI, page 91, did not reveal any findings which existed at a high level of dependability. Here, as in the field of mathematics, a tendency to favor programmed instruction was noted even though none of the specific findings could be highly rated. No available literature was found, however, to support conventional instruction as a more effective means of producing learning.

Objectives	High Ability			Average Ability			Low Ability			Mixed Abilities		
	PI[a]	NI[b]	CI[c]	PI	NI	CI	PI	NI	CI	PI	NI	CI
Facts												
Concepts												
Principles												
Understandings										3		
Application												
Transfer										3		
Unspecified											10	

FIGURE 8

COMPARATIVE EFFECTIVENESS OF PROGRAMMED INSTRUCTION AND CONVENTIONAL METHODS IN ENGLISH AT THE COLLEGE LEVEL

[a] Reliance indices favoring programmed instruction

[b] Neutral reliance indices

[c] Reliance indices favoring conventional instruction

TABLE VI

RESEARCH COMPARING THE EFFECTIVENESS OF PROGRAMMED INSTRUCTION WITH CONVENTIONAL METHODS IN SCIENCE

Investigation	Achievement level	Ability Level	Instructional objectives	PI[a]	NI[b]	CI[c]
Department of Research, and Planning and Publications	Junior High School Grade 7	High	Concepts	4		
		Average			4	
		Low			4	
Dutton	Elementary Grade 4	Average	Concepts	7		
Geller	College	Unspecified	Facts Principles		2	
Hatch Flint	College	Unspecified	Unspecified	3		
Jacobs	High School	Average	Concepts Principles Transfer	4		
Knirk	High School	Unspecified	Concepts		3	

[a] Reliance indices supporting programmed instruction

[b] Reliance indices which are neutral

[c] Reliance indices supporting conventional instruction

Programmed instruction in psychology. Only three available reports compared programmed instruction with the conventional methods in teaching psychology. All three experiments were conducted at the college level. Though none of the findings could be rated high in dependability, all supported the general conclusion that programmed instruction can be at least as effective as the traditional methods in teaching psychology to college students. Table VII, page 93, upholds Nauman's report in which he concluded that a psychology program is relevant and applicable for students studying educational psychology at the college level.[1]

Programmed instruction in other subject areas. The scarcity of available reports did not necessitate the construction of separate tables for the individual subject areas included in this section. Consequently, Table VIII, page 94, was organized to include all those reports which did not involve mathematics, science, English and psychology. The tabulation did not identify any highly dependable, specific findings. In general, the greater portion of the studies supported programmed instruction as being at least as effective as conventional techniques. This apparent efficacy of programmed instruction was further illustrated by three other somewhat differently designed studies. Brinkman found that the experimental group in Grade eight

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[1]Theodor F. Nauman, "A Laboratory Experience in Programed Learning for Students in Educational Psychology," The Journal of Programed Instruction, I;17, 1963.

TABLE VII

RESEARCH COMPARING THE EFFECTIVENESS OF PROGRAMMED INSTRUCTION WITH CONVENTIONAL METHODS IN PSYCHOLOGY

Investigation	Achievement level	Ability level	Instructional objectives	PI[a]	NI[b]	CI[c]
Ellison	College	Not specified	Concepts Recognition		2	
Maiser	College	Not specified	Facts	3		
Stone	College	Not specified	Concepts Problem solving Transfer		5	

[a] Reliance indices supporting programmed instruction

[b] Reliance indices which are neutral

[c] Reliance indices which support conventional instruction

TABLE VIII

PROGRAMMED INSTRUCTION COMPARED TO CONVENTIONAL METHODS IN OTHER SUBJECT AREAS

Investigation	Subject Area	Achievement level	Ability level	Instructional objectives	PI[a]	NI[b]	CI[c]
Campbell Bivens	Geography	Elementary Grades 5 and 6	Mixed	Facts Principles Application		4	
Green Weiss Nice	Parasitology	College	Unspeci- fied	Unspecified	4		
Hayman Johnson	Spanish	Elementary Grades 5 and 6	Average	Unspecified			5
Hough	Educational foundations	College	Unspeci- fied	Unspecified		5	
HRB-Singer, Inc.	Political Science	College	Unspeci- fied	Facts Understanding		4	

[a] Reliance indices supporting programmed instruction

[b] Neutral reliance indices

[c] Reliance indices supporting conventional instruction

TABLE VIII (continued)

Investigation	Subject Area	Achievement level	Ability level	Instructional objectives	PI	NI	CI
Hughes	Data processing	Unspecified	Mixed	Unspecified	4		
Legg	Agriculture	Junior and senior high school	Unspecified	Unspecified			
Pinkerton Hay	Business communication	College	Average	Concepts Transfer	6		
Rea Gray	Social studies	College	Unspecified	Understanding Transfer	3		
Shearer	Social science	College preparatory level	Unspecified	Facts Principles Application	3		
Smith	Medical terminology	High school	Average	Concepts Transfer Recall Recognition		3	
Wendt Rust	Library	College	Unspecified	Unspecified		6	
Wood	Social studies	Junior High School Grade 9	Average	Principles Transfer		5	
Wurtz	Driver education	Unspecified	Unspecified	Skills Transfer		3	

receiving programmed instruction in space relations made significant gains in geometry relative to a carefully matched control group both in content learning and in the transfer of training. Definite conclusions were impossible because Brinkman's control group received no instruction in spacial relations at all.[2] Hatch reported that pilots exposed to programmed instruction by machine improved significantly in their knowledge of inflight job information while those who were not exposed to this type of information did not improve.[3] Ferster showed that German could be taught with a great deal of success by using programmed instruction. His conclusions were based on an indirect comparison of the experimental group's performance to the achievement of previous groups who took whole semesters to accomplish the same amount of work.[4]

Programmed Instruction Compared with Conventional Materials

The diversity of subject areas and achievement levels along with the lack of specificity concerning instructional objectives and ability

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[2]Erwin Henry Brinkmann, "Educability in Visualization of Objects in Space: A Programmed Instruction Approach" (unpublished Doctoral dissertation, The University of Michigan, Ann Arbor, 1963), p. 71.

[3]Richard S. Hatch, An Evaluation of Effectiveness of a Self-Tutoring Approach Applied to Pilot Training (WADE Technical Report 59-320; Wright-Patterson Air Force Base, Ohio: Aero Medical Laboratory, Wright Air Development Center, Air Research and Development Command, United States Air Force, 1959), pp. 10-13.

[4]Charles B. Ferster, and Stanley M. Sapon, "An Application of Recent Developments in Psychology to Teaching of German," Harvard Educational Review, 28:59, January-December, 1958.

levels precluded the formation and evaluation of any specific conclusions. However, with the exception of only one study, all comparisons as shown by Table IX, page 98, indicated that programmed instruction was at least as effective as and in some cases superior to the conventional materials. Dahl found that his control group using the conventional teaching text scored significantly higher on the textbook final than the experimental group using programmed instruction. The experimental group, however, scored higher on the programmed material test.[5]

The Comparative Effectiveness of Program Characteristics

This part of the study was devoted to the analytical and evaluative survey of experimental reports concerned with the three following aspects of programmed instruction: the presentation, the response, and the confirmation or feedback.

Textbook presentation versus machine. The examination of Table X, page 100, revealed that the textbook presentation of programmed material was apparently equal in effectiveness to machine presentation of the same material. From a more specific point of view, only one conclusion was found to exist at the high level of dependability. It implied that mathematical concepts at the college level could be taught just as effectively by using either the textbook or the machine presentation of programmed material.

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[5]Ernest Dahl, "Report of an Experiment with Programmed Instruction in Trigonometry Using TEMAC" (Minneapolis, Minnesota: Fridley Senior High School, Independent School District, No. 14, 1963), p. 4. (Dittoed.)

TABLE IX

EFFECTIVENESS OF PROGRAMMED AND CONVENTIONAL MATERIALS

Investigation	Subject Area	Achievement level	Ability level	Instructional objectives	PM[a]	NI[b]	CM[c]
Angell	Chemistry	College freshmen	Unspecified	Facts Principles Application	4		
Culpepper	Algebra	Junior High School Grade 9	Unspecified	Problem solving	3		
				Principles		3	
Dodge	Technical mathematics	College	Unspecified	Skills Facts Comprehension Problem solving		4	
Ellison	Counselling	College	Unspecified	Concepts Recognition		2	

[a] Indices supporting programmed materials

[b] Neutral indices

[c] Indices supporting conventional materials

TABLE IX (continued)

Investigation	Subject Area	Achievement level	Ability level	Instructional objectives	PM	NI	CM
Feldhusen Birt	Psychology Programed learning	College	Unspecified	Concepts		5	
Green Weiss Nice	Medicine	College	Unspecified	Unspecified		4	
Hershberger	Geography Physiology Chemistry	Elementary Grade 6	Average	Facts Principles Concepts	4		
McLaulin	Arithmetic Grade 3	Elementary Grade 3	Average	Comprehension Problem solving	5		
Peck	Algebra	Junior High School Grade 8	Superior	Unspecified		5	
Rothkopf	Electricity Color code	College	Unspecified	Facts		3	
Stevens	Algebra	High School	Mixed	Unspecified		4	
Tohtz	English	College freshmen	Unspecified	Unspecified		4	
Unruh	Language	Junior High School	Mixed	Knowledge Understanding	5		
Wesson	Arithmetic Grade 4	Elementary	Mixed	Unspecified		5	

TABLE X

EFFECTIVENESS OF TEXTBOOK AND MACHINE PRESENTATION OF PROGRAMMED MATERIALS

Investigation	Subject Area	Achievement level	Ability level	Instructional objectives	TI[a]	NI[b]	MI[c]
Eigen Filep	Mathematics	Junior High School	Mixed	Unspecified		3	
Eigen Komoski	Mathematics	Collegiate	High	Transfer Unspecified		2	
Gotkin Golstein	Spelling	Elementary	Mixed	Meaning Transfer		5	
Heimer	Mathematics	College	Unspecified	Concepts Problem solving		5	
Hough Revsin	Educational foundations	College	Unspecified	Unspecified		7	
Moore Smith	Psychology	College	Unspecified	Unspecified		2	
Roe	Mathematics	College	Unspecified	Concepts		3	

[a] Reliance indices supporting the textbook presentation

[b] Neutral reliance indices

[c] Reliance indices supporting machine presentation of programmed instruction

Group versus individual pacing in programmed instruction. An indication that perhaps there is no difference between the effectiveness of grouped and individual pacing was implied by Table XI, page 102. When such factors as content, ability, achievement level and instructional objectives were considered, no finding was identified as being highly dependable.

Small steps versus large steps. Table XII, page 103, showed a tendency for the small step program to be more effective than the large step program. No high dependability findings were revealed by the table.

Use of repetition in presentation. Table XIII, page 104, disclosed no apparent indication as to whether or not repetition is a necessary characteristic of programmed instruction. The comparatively equal distribution of the supporting indices suggested that perhaps specific conditions influence the need for repetition. No finding of a highly dependable nature was found because of the lack of specificity of the data gathered. The possible influence of the prevailing circumstances upon the need for repetition was emphasized by Ferster[6] who reported results contrary to those of Holland and Porter[7] who used the

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[6]C. B. Ferster, "The Role of Review Material in Continuous Programming with Teaching Machines" (Bloomington: Indiana Medical School, no date), p. 3. (Mimeographed.)

[7]James G. Holland and Douglas Porter, "The Influence of Repetition of Incorrectly Answered Items in a Teaching-Machine Program," *Journal of Experimental Analysis of Behavior*, 4:305, October, 1961.

TABLE XI

EFFECTIVENESS OF GROUP AND INDIVIDUAL PACING IN THE PRESENTATION OF PROGRAMMED MATERIALS

Investigation	Subject Area	Achievement level	Ability level	Instructional objectives	GP[a]	NI[b]	IP[c]
Feldhusen Birt	Education Teaching machines Programmed learning	College	Unspecified	Concepts		5	
Frye	Modern mathematics	High School	Unspecified	Unspecified		4	
Lottes Palmer Oakes	Modern mathematics	College	Unspecified	Unspecified		5	
Moore Smith	Spelling	Elementary Grade 6	Mixed	Unspecified		2	

[a] Reliance indices supporting group pacing

[b] Reliance indices favoring neither group nor individual pacing

[c] Reliance indices supporting individual pacing

TABLE XII

THE EFFECTIVENESS OF LARGE AND SMALL STEP PROGRAMS

Investigation	Subject Area	Achievement level	Ability level	Instructional objectives	LI[a]	NI[b]	SI[c]
Campbell	Mathematics	Elementary Junior and Senior High School	High Average Low	Concepts Transfer			2
Hayman Johnson	Spanish	Elementary Grades 5 and 6	Average	Unspecified			5
Memmot	English grammar	Elementary Grades 4, 5, and 6	Mixed	Facts Concepts Application		3	
Smith Moore	English spelling	Elementary Grade 5	Mixed	Unspecified		4	
Shay	Mathematics Roman numerals	Elementary Grade 4	High Average Low	Understandings Facts		6	

[a] Indices supporting large step programs

[b] Neutral reliance indices

[c] Indices supporting small step programs

TABLE XIII

EFFECTIVENESS OF REPETITION IN PROGRAMMED INSTRUCTION

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	R[a]	NR[b]
Birch Stuckless	Grammar Composition	Unspecified (Deaf students)	Mixed	Unspecified	7	
Ferster	Psychiatry Psychology	College	Unspecified	Unspecified		2
Holland Porter	Psychology	College	Unspecified	Unspecified	3	
Meyer	Vocabulary	Junior High School Grade 8	Superior	Unspecified		3
Reynolds	Biology	Junior High School	Average High	Unspecified		3
Rothkopf	Mechanics	Unspecified	Unspecified	Facts		4

[a] Indices supporting repetition as a necessary factor in programmed instruction

[b] Indices implying that repetition is not necessary in programmed instruction

same program in their experiment.

Logical versus random sequence of item presentation. Every available report which was analyzed in this study supported random and logical sequences as being equally effective in the presentation of programmed instruction. According to the established criteria none of the specific findings implied by Table XIV, page 106, was rated as highly dependable.

Branched versus linear presentation of programmed materials. Branching and linear presentation of programmed materials were found to be equally effective in every case. However, no specific finding indicated in Table XV, page 107, was found to be highly dependable.

Inductive versus deductive approaches in program presentation. Only two studies were found in which the inductive method was compared to the deductive. In teaching facts, terms, relationships, principles and concepts in algebra to a group of Grade eight students, Belcastro found the verbal deductive approach to be significantly superior at all levels of ability.[8] Birch and Stuckless found both approaches to be equally effective in teaching grammar and composition

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[8]Frank P. Belcastro, "Programmed Learning: Relative Effectiveness of Four Techniques of Programming the Addition and Subtraction Axioms of Algebra." (unpublished Doctoral dissertation, The University of Pittsburgh, Pittsburgh, 1961), pp. 54-55.

TABLE XIV

COMPARATIVE EFFECTIVENESS OF LOGICAL AND RANDOM SEQUENCES IN PRESENTING PROGRAMMED MATERIALS

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	LI[a]	NI[b]	RI[c]
Gavurin	Psychology	Unspecified	Unspecified	Concepts Facts		1	
Levin	Geometry	Elementary Grade 2	Unspecified	Unspecified Transfer		5	
Stolurow	Mathematics Fractions	Elementary Grade 5	Retarded adolescence	Unspecified Transfer		2	
Roe Case Roe	Psychology	College freshmen	Unspecified	Concepts		2	
Raygor Wark	Developmental reading	College	Unspecified	Understandings		2	

[a] Reliance indices supporting the logical sequence in presentation

[b] Neutral reliance indices

[c] Reliance indices supporting the random sequence in presentation

TABLE XV

COMPARATIVE EFFECTIVENESS OF LINEAR AND BRANCHING PROGRAMS

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	LP[a]	NI[b]	BP[c]
Beane	Geometry	Senior High School	High Low	Concepts Principles		3	
Coulson Silberman	Psychology	College	Unspecified	Principles Transfer		4	
Melaragno Silberman Coulson	Logic	Junior and Senior High School	Unspecified	Unspecified Transfer		3	
Roe	Mathematics	College freshmen	Unspecified	Concepts		4	
Silberman Melaragno Coulson	Logic	Junior college	Unspecified	Transfer		2	

[a] Reliance indices supporting linear programming

[b] Neutral reliance indices

[c] Reliance indices supporting branched programming

to adolescent deaf students.[9] Neither finding was rated as highly dependable.

Comparative effectiveness of question and statement methods in presenting programmed materials. The two available experimental reports both stated that the question and statement forms of program presentation were equally effective in teaching science. Herrick's investigation revealed no significant difference in performance between junior high school groups using problem-setting questions and those using the statement form in presenting the same content material.[10] At the elementary level, McNeil and Keislar reported that the presentation of a program in question form was just as effective as the presentation in statement form for all characteristics of the learner.[11] According to the criteria used in this study none of the possible specific conclusions could be considered highly dependable.

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[9] Jack W. Birch and E. Ross Stuckless, "Programed Instruction and the Correction of Written Language of Adolescent Deaf Students" (a research report, Special Education and Rehabilitation, School of Education, University of Pittsburgh, Pittsburgh, 1963), p. 45. (Mimeographed.)

[10] Merlyn Charles Herrick, "The Effect of Problem-Setting Questions on Rate and Amount of Learning in Programming Teaching Machines" (unpublished Doctoral dissertation, Indiana University, Bloomington, 1962), p. 31.

[11] John D. McNeil and Evan R. Keislar, "Individual Differences and Effectiveness of Auto-Instruction at the Primary Grade Level," California Journal of Educational Research, 12:162, September, 1961.

Combined teacher and program presentation versus program presentation alone. Ellson et al. conducted a study in which the effectiveness of classroom and program procedures was compared to that of a program procedure alone. They found that a group of retardates made significantly greater gains in vocabulary when the combined approach was used. The two methods were equally effective with respect to comprehension.[12] Goldbeck et al. used the combined approach in teaching social science to a group of college preparatory students. They reported that the combined approach was significantly more effective than the program presentation alone.[13] Although there was an indication that perhaps the combined approach to the presentation of learning material was superior to the program presentation alone, no highly dependable, specific finding was identified.

Selective reference versus complete presentation. Bivens, Campbell and Terry performed a study in which they found that self-directing and self-evaluating programs were just as efficient and effective as the conventional linear programs in teaching grade nine

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[12] D. G. Ellson et al., "Comparison of Methods of Combining Classroom and Program Procedures," Programmed Teaching of Elementary Reading -- a Progress Report, Experiment V (Bloomington: University of Indiana, 1962), p. 11.

[13] Robert A. Goldbeck et al., Integrating Programed Instruction with Conventional Classroom Teaching. AIR-C49-12/62-FR, Final Report (San Mateo: American Institute for Research, December, 1962), p. 17.

mathematics to a group of low ability students.[14] Wahler found that a diagnosis of difficulty and selected reference to specific frames of a program produced better results than just a complete presentation of the entire program. His experiment involved teaching punctuation in grammar to a group of average and below average grade ten students.[15] Neither finding was rated highly dependable.

Constructed response versus non-constructed response. Tables XVI, XVII and XVIII showed that the non-constructed response was generally as effective as the constructed response with some tendency for the constructed response to be superior. No highly dependable findings were identified. Lambert, Miller and Wiley reported a study in which they compared the two modes of response in mathematics at the high school level. Their findings, although not highly dependable, supported the indication that the two response modes were equally effective.[16]

Response versus no response in programmed instruction. As shown by Table XIX, page 115, most studies supported the finding of no

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[14] Lyle W. Bivens, Vincent N. Campbell and Donald F. Terry, Self-Direction in Programed Instruction: Effects on Learning in Low Ability Students, AIR-DIO-7/63-TR, Technical Report (Palo Alto: American Institute for Research, July, 1963), p. 7.

[15] Theodore G. Wahler, "A Selective Reference System," NSPI Journal, II:14, November, 1963.

[16] Philip Lambert, Donald M. Miller and David E. Wiley, "Experimental Folklore and Experimentation: The Study of Programmed Learning in the Wauwatosa Public Schools," Journal of Educational Research, 55:491, June-July, 1962.

TABLE XVI

CONSTRUCTED VERSUS NON-CONSTRUCTED RESPONSE AT THE ELEMENTARY LEVEL

Investigation	Subject area	Ability level	Instructional objectives	CI[a]	NI[b]	NCI[c]
Andrews	Mathematics	Superior Average Low	Concepts Principles		4	
Hershberger	Physiology History	Mixed	Unspecified	3		
Kalk	Spelling	Retarded	Rote learning	3		
McNeil Keislar	Molecular theory	Mixed	Concepts Understandings Transfer		4	
Price	Addition	Retarded	Operations Problem solving Discrimination		4	
______	Subtraction	______	______			4
Whittrock	Molecular theory	Unspecified	Concepts	3		

[a] Reliance indices supporting the constructed response

[b] Neutral reliance indices

[c] Reliance indices supporting the non-constructed response

TABLE XVII

CONSTRUCTED VERSUS NON-CONSTRUCTED RESPONSE AT THE JUNIOR HIGH LEVEL

Investigation	Subject area	Ability level	Instructional objectives	CI[a]	NI	NCI
Ashbaugh Experiment I	Science Molecular theory	High	Concepts			4
		Average			4	
		Low			4	
Ashbaugh Experiment	Modern Mathematics	High Average Low	Concepts		4	
Eigen Margulies	Nonsense words	Unspecified	Rote learning	3		
Fry	Spanish vocabulary	Average	Rote learning	2		
Goldbeck Campbell	History Geography	Above average	Facts (High level of difficulty)	2		
			Facts (Low level of difficulty)			2
Goldbeck Campbell	Physics Light	High Average	Facts		3	
Unruh	English Grammar	Mixed	Concepts Application Understandings		5	

[a] See Table XVI, page 111.

TABLE XVIII

CONSTRUCTED VERSUS NON-CONSTRUCTED RESPONSE AT THE COLLEGE LEVEL

Investigation	Subject area	Instructional objectives	CI[a]	NI	NCI
Coulson Silberman	Psychology	Principles Transfer		4	
Cummings Golstein	Medicine Myocardial infraction	Unspecified	4		
Della-Piana	Counseling	Unspecified		5	
Evans Glaser Homme	Symbolic logic	Facts Application		4	
Goldbeck Shearer Campeau Willis	Social Science Federal government	Facts Principles Application	3		
Hough	Educational foundations	Unspecified		5	
Krumbholtz Weisman	Educational psychology	Conceptual understanding	3		

[a] See Table XVI, page 111.

TABLE XVIII (continued)

Investigation	Subject area	Instructional objectives	CI[a]	NI	NCI
Moore Smith	Psychology	Unspecified		2	
Ripple	Psychology	Principles	5		
Silverman Alter	Basic electricity	Unspecified		3	
Stolurow Walker	Descriptive statistics	Unspecified		3	
Tobias Weiner	Binary numbers	Conceptual understanding Application		4	
Williams	Psychology	Unspecified		2	
Yarmey	Psychology	Unspecified		2	

[a] See Table XVI, page 111.

TABLE XIX

EFFECTIVENESS OF PROGRAMS REQUIRING A RESPONSE AND THOSE WHICH DO NOT REQUIRE A RESPONSE

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	RI[a]	NI[b]	NRI[c]
Feldhusen Birt	Psychology Teaching machines and programed learning	College	Unspecified	Concepts		5	
Holland	Psychology	College	Unspecified	Concepts	0		
Keislar McNeil	Science Kinetic theory of molecules	Elementary Grades 1, 2, and 3	Unspecified	Principles Application		7	
McDonald Allen	Board game	Senior High School	High	Unspecified		4	
Roe	Elementary probability	College	Unspecified	Concepts		3	

[a] Indices supporting programs in which a response is required

[b] Indices which indicate that both are equally effective

[c] Indices supporting programs in which no response is required

TABLE XIX (continued)

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	RI	NI	NRI
Silverman Experiment I	Basic electricity	College	Unspeci- fied	Unspecified		5	
Silverman Experiment II	Binary numbers	College	Unspeci- fied	Unspecified		4	
Tobias Weiner	Binary numbers	College	Unspeci- fied	Conceptual understanding Application		4	
Williams	Psychology	College	Unspeci- fied	Unspecified	2		

difference in effectiveness between a program requiring a response and one which does not. This seemed inconsistent with the findings of the previous section in which a strong tendency to favor constructed response programs was revealed. None of the specific findings rated high in dependability.

Delayed versus immediate confirmation. No specific finding contained in Table XX, page 118, was rated as highly dependable. From the overall point of view, it was found that the indices supported the conclusion that immediate confirmation was as good or better than delayed confirmation.

Type of confirmation. Alter, Eigen and King found that confirmation alone was just as reinforcing or effective as confirmation and trinkets in teaching quantitative concepts and numbers to five and six year old children representing a heterogeneous ability group.[17] Melaragno tested the hypothesis that some negative reinforcement in an autoinstructional setting does not hinder learning at the junior college level.[18] He found that massed negative reinforcement was less effective than spaced negative and positive reinforcement. Although the findings were not judged to be highly dependable, they indicated

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[17] Millicent Alter, Lewis Eigen and Shirley King, *The Effectiveness of Confirmation Plus Trinket Reinforcers in Young Children* (New York: The Center for Programed Instruction, No date), p. 4.

[18] Ralph J. Melaragno, "Effect of Negative Reinforcement in an Automated Teaching Setting," *Psychological Reports*, 7:384, July-December, 1960.

TABLE XX

EFFECTIVENESS OF DELAYED AND IMMEDIATE CONFIRMATION

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	II[a]	NI[b]	DI[c]
Evans Glaser Homme	Symbolic logic	College	Unspecified	Memorization Application		4	
Feldhusen Birt	Psychology	College	Unspecified	Concepts		5	
Meyer	Vocabulary Prefixes	Junior High School Grade 8	Superior	Unspecified	3		
Raygor	Developmental reading	College	Unspecified	Understanding		2	
Ruehl	Electricity	College	Mixed	Acquisition Application Problem solving	7		

[a] Indices supporting immediate confirmation

[b] Neutral indices

[c] Indices supporting delayed confirmation

that perhaps confirmation was not a particularly important aspect of programmed instruction.

Feedback versus no feedback in programmed instruction. Table XXI, page 120, showed that programs without a built-in provision for feedback were just as effective in most cases as the programs with the provision for feedback. Only one specific finding was rated as highly dependable. It implied that concepts in college psychology can be taught just as effectively by programs which do not utilize a provision for feedback. The need for feedback was demonstrated by a study conducted by Stolurow and Lippert who found that confirmation was more effective when a high level of overlearning was required.[19] When, however, a low level of learning was the objective, the ordinary prompting sequences were more effective in producing rapid learning. Since Stolurow's and Lippert's subjects were educable handicapped children, one cannot generalize in interpreting the results of their findings.

Effect of ability on achievement in programmed instruction. A larger portion representing a greater number of the more reliable studies supported the finding that programmed instruction does not reduce the dependency of learning upon ability. Among the specific findings included in Table XXII, page 122, only two were rated as highly dependable. These indicated that the dependence upon ability to learn

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[19]Lawrence M. Stolurow and Henry Lippert, Prompting, Confirmation and Vanishing in Teaching of a Sight Vocabulary (Urbana: Institute for Research on Exceptional Children, University of Illinois, April, 1962), p. 21.

TABLE XXI

THE EFFECTIVENESS OF PROGRAMS WITH AND WITHOUT THE PROVISION FOR FEEDBACK

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	FI[a]	NI[b]	NFI[c]
Blackman Holden	Spelling	Unspecified	Retarded	Unspecified		3	
Cook Spitzer	No specific content	College	Unspecified	Memorization			2
Feldhusen Birt	Psychology	College	Unspecified	Concepts		5	
Hessert	Logic	Senior High School Grade 11	High Average	Concepts Application		6	
Holland	Psychology	College	Unspecified	Concepts	0		
Hough Revsin	Educational foundations	College	Unspecified	Unspecified		7	

[a] Indices supporting the provision for feedback

[b] Indices supporting the finding of no difference

[c] Indices supporting the superiority of no provision for feedback

TABLE XXI (continued)

Investigation	Subject area	Achievement level	Ability level	Instructional objectives	FI	NI	NFI
Krumbholtz Weisman	Psychology	College	Unspeci- fied	Principles Understandings		4	
McDonald Allen	Board game	Junior and Senior High School	High	Unspecified		4	
Moore Smith	Spelling	Elementary Grade 6	Mixed	Unspecified		4	
Ripple	Psychology	College	Unspeci- fied	Principles		5	
Moore Smith Experiment I	Spelling	Elementary Grade 6	Mixed	Unspecified		2	

TABLE XXII

DEPENDENCE OF LEARNING UPON ABILITY IN PROGRAMMED INSTRUCTION

Investigation	Subject area	Achievement level	Instructional objectives	RI[a]	NRI[b]
Andrews	Mathematics Enumeration	Elementary Grade 6	Concepts Principles		4
Belcastro	Algebra	Junior High School Grade 8	Facts Principles Concepts Application		6
Bivens Campbell Terry	Mathematics Set theory	Junior High School Grade 9	Concepts	1	
Blank	Inquiry	Elementary	Unspecified Transfer	4	
Brinkmann	Space relationship	Junior High School Grade 8	Problem solving Transfer		7

[a] Indices supporting the conclusion that programmed instruction reduces the dependence of learning upon ability.

[b] Indices supporting the conclusion that programmed instruction does not reduce the dependence of learning upon ability.

TABLE XXII (continued)

Investigation	Subject area	Achievement level	Instructional objectives	RI	NRI
Brown	Mathematics	Junior High School Grade 9	Principles Skills Concepts		2
Fillmer	English verb usage	Elementary Grade 4	Unspecified		6
Gorow	Statistical analysis	College	Concepts Transfer Problem solving Understandings	3	
Green Weiss Nice	Medicine (parasitology)	College	Unspecified	4	
Hatch Flint	Electronics	College	Unspecified	3	
Herrick	Physics (light and color)	Junior High School	Facts	7	
Jacobs	Chemistry	Senior High School	Concepts Principles Transfer	4	
Kalk	English spelling	Unspecified	Memorization		3
Knudson	English	Junior High School Grade 7	Unspecified		7

TABLE XXII (continued)

Investigation	Subject area	Achievement level	Instructional objectives	RI	NRI
McNeil Keislar	Molecular theory	Elementary Grades 1, 2, and 3	Concepts Understandings Transfer		7
Miller	English punctuation	Senior High School Grades 10 and 11	Acquisition Transfer	4	
Moses	Algebra	Junior High School	Unspecified		3
Northcutt	Mathematics (decimals)	Elementary Grade 5	Skills Facts Concepts		6
O'Toole	Spelling	Elementary Grades 5 and 6	Unspecified		5
Porter	Spelling	Elementary Grade 6	Unspecified Transfer	3	
Research Department Toronto Schools	English	Junior High School Grade 8	Unspecified	4	
Roe Case Roe	Probability and statistics	College	Concepts		2

TABLE XXII (continued)

Investigation	Subject area	Achievement level	Instructional objectives	RI	NRI
Shay	Mathematics Roman numerals	Elementary Grade 4	Principles Understandings Memorization		6
Stanton	English	Junior High School Grade 9	Unspecified		6
Stolurow Lippert	Vocabulary	Unspecified	Concepts Memorization		3
Troemel	Spelling	Unspecified	Unspecified Transfer	4	
Unruh	English	Junior High School Grade 7	Concepts Understandings Application	5	

concepts and principles in mathematics at the elementary and the junior high school level was not reduced by programmed instruction. Conflicting evidence did not permit specific findings in other subject areas and at other ability levels to be rated as highly dependable.

III. COMMENTS

Generally, the major portion of the findings supported programmed instruction as being at least as effective as the conventional methods in producing learning. However, it was found that an application of an evaluative criteria to specific situations involving instructional objectives and the characteristics of the learner did not reveal as many dependable findings as one might have expected from the general trend. This relatively small portion of dependable findings was largely attributed to the grossness of the research. The analysis revealed a particularly great need for more research of a very specific nature in new subject areas as well as in those in which some investigation has already been made.

This criticism of grossness applied also to research concerning the nature of the programs and their relationship to effectiveness of instruction. The study showed that very little has actually been accomplished in determining the relationship between the specific characteristics of the program and those of the instructional objectives and the learner.

CHAPTER III

SUMMARY AND CONCLUSIONS

The past decade has seen the emergence and rapid development of what some educators refer to as the "major break through" in education. Because the pace of research in programmed instruction has been unusually rapid, it was decided that an intensive evaluative survey of the experimental work in this area would be very beneficial in revealing more vividly the potentialities of the method. Briefly, the problem was to find and evaluate the answers to a number of frequently asked questions concerning the field of programmed instruction.

I. THE PROCEDURES USED

To achieve the purpose of the study, the available research reports were evaluated according to a set of eight criterion items considered to be an adequate representation of the elements of acceptable research procedure. The evaluation consisted principally of assigning to each report a reliance index which indicated the number of criterion items that it satisfied. These reliance indices were subsequently utilized as an expression of supporting power in determining the dependability of the answers to the questions posed in the study. The data and the findings obtained from the analysis of the individual reports were tabulated in order to identify the answers to the questions and to determine the strength of the support they received

in terms of the indices derived from the previous evaluation of the reports. The strength of the support or the dependability level as it was referred to throughout the study was determined by dividing the sum of the supporting indices by the total of all indices pertinent to the specific findings involved. The findings which served as answers to the questions were considered highly dependable when the ratio of the supporting indices to the total indices involved resulted in 0.9 or higher. The minimum supporting indices were set at 8, a number which represented the reliance index of a study or report that satisfied every item in the list of evaluative criteria. In general, the design of this documentary survey was a major modification of that used by Marrone in his analysis of scientific research in phonics.[1] The purpose of the modification was to increase the objectivity of the study without unduly discrediting the nature of the investigations used as sources of data in this study.

II. FINDINGS AND CONCLUSIONS

The Evaluation of Individual Reports

Figure 9, page 129, shows the extent to which each criterion item was satisfied by all the reports analyzed in this study. Explanation of terms, the error rate of programs and the reliability of the instruments used were found to be the most neglected items of the

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[1]Victor Eugene Marrone, "A Critical Analysis of Scientific Research in Phonics" (unpublished Doctoral dissertation, University of Pittsburgh, Pittsburgh, 1958), pp. 17-18.

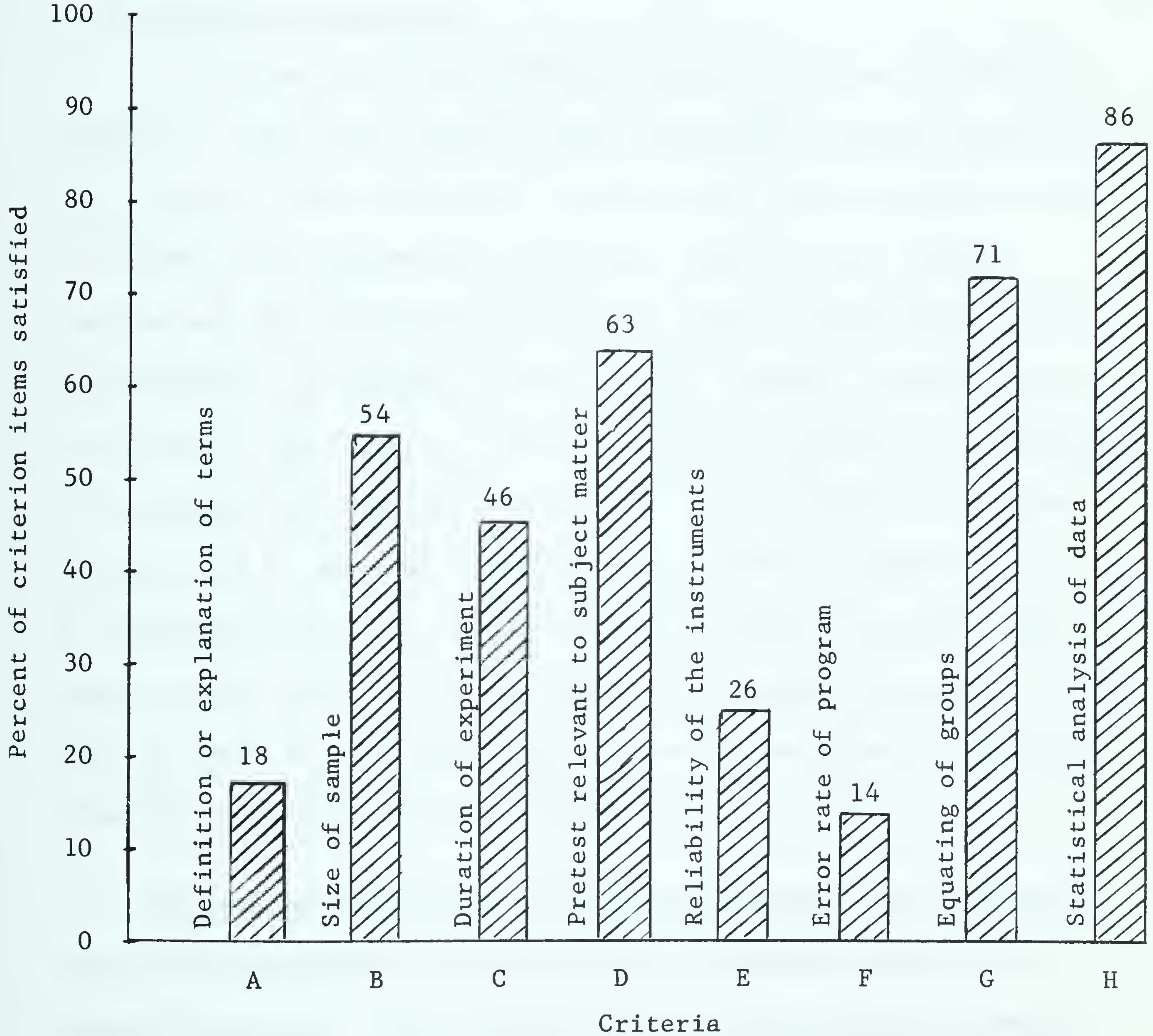

FIGURE 9

PERCENTAGE OF STUDIES SATISFYING
EACH OF THE CRITERION ITEMS

criterion list. The criterion items most adequately represented were those concerning the equating of groups and the statistical analysis of data.

The Identification and Evaluation of the Specific Findings Pertinent to the Delimiting Questions

Of the many specific findings included in Tables I to XXII of Chapter II, only those rated as highly dependable received emphasis in this section. The conclusions, in most cases, were expressed in terms of content area, achievement and ability levels of the learners involved and the instructional objectives which included memorization, understanding, application of the acquired learnings, learning of facts and concepts, and transfer. The decision to be specific in identifying and evaluating the findings was based on the rationale that maximum utility could be achieved by minimizing reference to generalities. In situations where some reports did not include the specific data required, this technique did not prove to be entirely successful. However, in spite of this shortcoming, the method was found to be quite effective in reducing deceptive apparencies.

Programmed instruction in exceptional cases. Every available study found programmed instruction to be at least as effective as ordinary procedures. The detailed analysis and evaluation revealed one highly dependable finding which indicated that programmed instruction was at least as effective as ordinary methods in teaching the recognition of words in spelling or reading to mentally retarded pupils.

Programmed instruction versus conventional techniques in various subject areas and at different ability and achievement levels. This section attempted to provide answers to questions concerned with the subject areas and the ability and achievement levels at which programmed instruction could be used successfully. Since the success of programmed instruction was determined on the basis of what conventional instruction could do in similar circumstances, the method also provided some answers as to which is the more effective of the two methods.

In mathematics, at the elementary level, there was a tendency to favor programmed instruction as the more effective method of instruction. The conclusion with the high dependability level implied that the two methods were equally effective in teaching problem solving.

At the junior high school level, a greater tendency to support programmed instruction as the superior method of teaching mathematics was noted. The highly dependable finding at this achievement level revealed the two methods to be equally effective in attaining unspecified objectives with mixed ability groups.

No highly dependable findings were identified concerning mathematics at the senior high school level. The studies, in general, tended to support the two techniques as being equal.

The most successful utilization of programmed instruction in mathematics seemed to occur at the college level. Here, the findings indicated that the two methods were equally effective in teaching concepts, understandings, application of the acquired knowledge, and

transfer.

In English at all levels of ability and achievement, programmed instruction was, in most cases, found to be as effective as the traditional methods. A number of high level findings were identified within this subject area. The two methods were equally effective in teaching concepts to high ability groups and, facts, concepts and unspecified learning material to average ability groups at the elementary level. At the junior high school level the conventional methods were found to be equally effective to programmed instruction in teaching understandings and other unspecified learning material to heterogeneous ability groups. No difference in effectiveness between the two methods was found in attaining unspecified learning objectives with the average and below average ability groups at the senior high school level; however, programmed instruction proved to be more effective with the high ability groups. No difference in effectiveness to teach unspecified learning material in English at the college level was found.

In other subject areas, the general trend supported the majority of findings in English and mathematics which showed that the two methods of instruction were equally effective. No highly dependable findings were identified in other content areas such as psychology, social studies and science.

Programmed instruction versus conventional materials. All comparisons indicated that programmed instruction was at least as effective

as, and in some cases superior to, other instructional materials. None of the specific findings rated highly in dependability. The conventional materials were represented by standard textbooks in most cases.

The Comparative Effectiveness of Program Characteristics

Numerous tendencies were noted concerning the methods of presentation, response and confirmation or feedback in programmed learning. With respect to the presentation of programmed materials it appeared that:

1. The textbook presentation was equally effective to the machine presentation of the same material.

2. The individual and group pacing were equally effective.

3. The small step was superior to the larger step.

4. Repetition did not always add to the effectiveness of the program.

5. There was no difference in effectiveness between logical and random presentation of programmed materials.

6. Branched programs were equally effective to the linear type.

7. There was no difference in effectiveness between the inductive and the deductive approaches in presenting programmed material.

8. Programs in question form were equally effective to programs in statement form.

9. There seemed to be some advantage in combining the teacher and program methods.

The analysis of research reports concerned with the response in programmed instruction indicated that the non-constructed response was generally as effective as the constructed response with some tendency for the constructed response to be superior, and that in many cases a program requiring no response was just as effective as one which requires some form of response. With regard to confirmation or feedback it was noted that little difference in favor of immediate confirmation existed between the effectiveness of immediate and delayed confirmation. Further observation indicated that in the majority of cases where programs with a provision for feedback were compared to those without, there was no difference in effectiveness. It was also noted that the type of confirmation seemed to have little relation to the effectiveness of the program. Application of the dependability formula to the indices supporting the specific findings showed the following to be highly dependable: textbook and machine presentations of programmed materials in college mathematics were equally effective in teaching concepts; and programs with a provision for feedback were equally effective to those without an arrangement for feedback in teaching concepts in psychology at the college level.

Achievement in Programmed Instruction as a Function of Ability

Although the individual studies were almost equally divided in their support of programmed instruction as a potential for reducing the learner's dependence upon his ability, the highly dependable findings supported the conclusion that programmed instruction had no such power

when compared to conventional teaching. These findings indicated that the dependence upon ability to learn concepts and principles in mathematics at the elementary and the junior high school level was not reduced by programmed instruction.

III. DISCUSSION

The very small number of highly dependable findings revealed by the application of the evaluative criteria supported the general conclusion that programmed instruction was at least as effective as conventional methods. It seems highly probable that any further comparison of conventional and programmed instruction will serve to produce a greater number of highly dependable findings which will support the general conclusion reached in this study. The greatest weakness in the evidence was found to be the lack of important details. Many writers neglected to describe either the program or the objectives to be achieved. In a number of cases the purpose of the instruction was stated as being the acquisition of knowledge with no attempt made to elaborate on the meaning of the term and its relation to the experiment. There was no precision in the definition of "conventional instruction." In most cases it represented some nebulous method which involved a live instructor. It was generally assumed that a small number of two or three instructors was an adequate representation of the traditional method. Furthermore, the teachers used in the experiments were selected on the basis of being highly competent. The fact that all the teachers involved in the experiments were very much aware

that they were being used in evaluating programs could also have influenced the results. In numerous cases there was no attempt made to separate the subjects into specific ability groups; as a result, it was very difficult to determine which type of student could benefit most from programmed instruction. In concluding, it may be said that even though programmed instruction was found to be as effective as the conventional techniques, much remains uncertain with respect to the specific learning situations.

Since very little has been established concerning the characteristics of programmed instruction and their effect upon the learning process, it may be inferred that the meaning of programmed instruction has been fixed by definition only and not by its effectiveness to instruct. Specifically, the effectiveness of programmed instruction does not seem to depend upon the nature of the factors implied in the usual definition of the term, namely: presentation, response and confirmation or feedback. This suggests that programmed instruction could best be defined, at least for the moment, as any method found to be effective in producing learning and which does not directly involve the teacher.

Perhaps the chief advantage of programmed instruction over any other type of instruction is its rather impressive superiority in efficiency. Every study which reported a comparison of efficiency found programmed instruction to be more efficient than the conventional methods. This feature alone would justify greater use were it not for the problem of administration which would involve such matters as

orientation of present teaching staffs, training of new teachers, selection and production of programs, providing new facilities, and modifying promotion policies. As a result, any future developments in the utilization of programmed instruction will probably take place at the local level where the danger of becoming too involved will not be as great. Unfortunately there is a danger at this level of programmed instruction becoming a victim of slip shod experimentation which could act as a deterrent in any possible and widespread adoption of its use. To avoid this, it would be desirable for such institutions as the University, the Department of Education and the Alberta Teachers' Association to direct certain pilot projects in an effort to investigate the feasibility of encouraging the use of programmed instruction in our schools.

IV. RECOMMENDATIONS FOR FURTHER RESEARCH

The first recommendation is that many of the previous experiments be replicated with emphasis on specific things. It has been shown by this survey that gross experiments reveal interesting tendencies which are severely limited when reference to them is made in dealing with specific issues. With respect to new research, Figures 1 to 8 of the previous chapter are vivid indications of the different types of experiments which could be recommended for the purpose of determining the feasibility of programmed instruction in various other content areas. For instance, Figure 2, page 77, shows that very little experimentation has been done in programmed mathematics with average and low ability

groups at the junior high school level. Similarly, the figures reveal that the problem of transfer has received very little attention compared to other instructional objectives.

It is further recommended that the principle of specificity be carefully adhered to in performing experiments concerning the characteristics of programmed instruction. For example, it may be that the effectiveness of a program characteristic is dependent upon the learner's ability and the type of instructional objective to be achieved. Gross experiments are not likely to disclose these relationships.

The final recommendation concerns the evaluation of programs. Many experiments involve two processes, namely: the construction and the evaluation of a certain program. In most cases this is done by comparing the effectiveness of the program with that of the instruction given by one or a small group of teachers to a classroom of students. Such a design has two glaring weaknesses: (1) a small group of teachers does not represent a typical teacher, and (2) in a classroom situation there is no ideal teacher-to-student relationship so that in effect the findings are actually the results of a comparison between the effects produced by group and individual treatments. Briefly, it is the effectiveness of the circumstances surrounding the instructional procedure that is being investigated and not the instruction itself. A more appropriate and accurate evaluation would involve a large sample of teachers adequately representing a particular teaching force. Each teacher from this sample would then be randomly assigned to one member

of a homogeneous group of learners representing the control subjects. A similar group of experimental subjects would be given the program treatment. It is felt that the results produced by this design could more justifiably be considered an evaluation of programmed instruction.

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APPENDIX

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